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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES EQUIPMENT AND SUPPLIES ASSOCIATION.

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All Hands to the Plough.

During the past few years we in this country have been considerably exercised in our minds to discover the secret of American prosperity—for American prosperity is clearly apparent even to those whose judgment is based on no sounder indication than the universal ownership of Ford cars. Delegations, official and unofficial, have visited the United States, reports have been issued and theories propounded, but how much this effort has achieved is a little uncertain.

The latest contribution to the symposium comes from an American, and takes the form of a Paper recently read to the Iron and Steel Institute. The author assumes that the basic industries may be taken to typify the industry of a country as a whole, and that iron and steel typify not inadequately the basic industries of the United States. On an examination of the progress of the iron and steel industry in the United States, therefore, he propounds a thesis of American prosperity.

It is widely known that the wealth per head of the population of the United States is considerably in excess of that of any other country, and that this wealth has increased notably over the last twenty-five years. This, it is shown, is due in one way or another to the increased productivity of the individual worker, since an increase in wealth per head means an increase in national wealth greater than the parallel increase in population over the same period. It is stated that the average man in a modern American iron and steel plant is producing from 1½ to 8 times as much as he did twenty-five years ago, while official data give an average increase throughout the industry of 165 per cent. from 1899 to 1926.

How has this tremendous increase in productivity been brought about? The author enumerates a number of points, but he stresses in particular the three that may be briefly summed up as labour, organisation, and power. It is the fact that Trade Unionism is weak in the United States, partly because many employers are strong enough to insist on the open shop, and again partly because there is a greater mobility from one rank of industry to another than exists in this country. The real difference, moreover, is not so much that there is a greater divergence in this country than in America between the interests of employer and employed, but that in this country there is a carefully fostered belief in such a divergence, which has just as fatal an effect on the men's point of view.

As to organisation, the immense benefits of large-scale business on American lines are advanced—the economies involved in the formation of trusts, and the slight danger to the public that lies in this method as regulated in the United States.

Lastly, we are given an explanation of the increased productivity that is the most convincing of all. We are told that there is now 4½ h.p. behind every manufacturing wage-earner in the United States, and that in the iron and steel trade the figure is as high as 16 h.p.—this being very largely the creation of recent years.

The conclusion that emerges is that there is no one factor that has, like a sort of magician's wand, created prosperity in America and which might with suitable propitiation be pressed into our own service. That prosperity is the result of many influences working in the same direction and many individuals with the same aim. The enlargement of the unit, the creation of real goodwill between employer and employed, the widespread introduction of up-to-date power—each has its own vital part to play, but neither alone can solve the problem of prosperity.

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Rammed Linings.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—The explanation given in your issue last week as to the increased length of rammed linings over fire brick linings for cupolas by an anonymous author on p. 264 is to my mind unsatisfactory. Plastic refractories owe their best properties through no portion being unduly compressed so as to lower the average melting point. If only a brick wall could be *perfectly* constructed so as to eliminate every unevenness which can and does create heavy local pressures, then lives comparable with monolithic linings should be obtainable. Extra efficiency is gained because the rammed material is of lower average heat conductivity than bricks, owing to the presence of minute globules of entrapped air, thus rendering the utilisation of a heat insulator between the iron work and the refractory unnecessary.—Yours, etc.,

CERAMICUS.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—I have read the article on ramming in the last issue of the JOURNAL with great interest and I should be much obliged if you will tell me what kind of rammers should be used on the job, and the temperature to which they require to be heated.—Yours, etc.,

WM HARPER.

16, Holtwhite Avenue, Enfield, Middlesex.
September 23, 1927.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—With reference to article on ramming in your last issue, will you kindly inform me if the author advocates the use of iron bricks facing the charging door, and, if so, to what depth should they be carried down the shaft?—Yours, etc.,

N. A. DAVIES.

28, Struass Villas, E. Finchley, N.2.
September 24, 1927.

Publications Received.

The Electrical Industry and the Consumer, published by the Electrical Publicity Bureau, 36, Kingsway, London, W.C.2. Price 1s. net.

Unhesitatingly, we designate this 10-page demi-quarto pamphlet as one of the cleverest pieces of propaganda for co-operation in industry ever printed. It gives a table of prices costs in the electrical industry from 1920 onwards, taking that year, when consequent on the ability of the industry to raise new capital for re-equipment and improvement of manufacturing processes, disturbed conditions of production owing to the perpetual effort to reduce wages as well as profits below an economic level, and the complete inability of the industry to meet foreign competition, especially if the latter, is extremely highly organised. We hope that every foundry owner will buy this little book and make an effort to put their business in an economic position similar to that of the electric industry. Co-operation was instituted as 100. It shows that exports have materially increased, that its workers are relatively better paid; that wholesale prices have been reduced; and that the price of electricity to the consumer has been reduced; that the efficiency of power stations has been improved. There is one paragraph which we consider that the foundry industry should assimilate and apply, that is "unrestricted competition leads to destruction of the real profit-earning capacity of the industry, with its consequence in the inability of the industry to raise new capital for re-equipment and improvement of manufacturing processes, disturbed conditions of production owing to the perpetual effort to reduce wages as well as profits below an economic level, and the complete inability of the industry to meet foreign competition, especially if the latter . . . is highly organised."

Random Shots.

Criticisms are often to be heard to the effect that the Papers presented to the metallurgical institutions are of so purely academic a nature that it is difficult to persuade the man engaged in industry to pit himself against his academic friends—better informed, perhaps, but inexperienced when it comes to practice. Some of the Papers read last week at the Iron and Steel Institute meeting in Glasgow were of so practical a nature as to furnish some sort of answer to these criticisms. Striking examples are the Papers on the influence of coke-ash on blast-furnace working, and on high-frequency melting, while the Paper on drying blast by silica gel is an outstanding contribution. It gives full details of what may possibly be considered the most important large-scale experiment in practical blast-furnace working within the past few years. Another interesting Paper dealt with the iron and steel industry of America from the economic-cum-social point of view.

* * *

The lights of Paris are beginning to fade into the distance, but there are still just a few points on which our curiosity remains unsatisfied. We should like to know for instance:—

Where a certain Scottish friend of ours suddenly acquired so much knowledge of history, and whether it helped him in his more frivolous adventures during the week?

Whether the much admired and respected secretary of the I.B.F. has yet lost the worried look that settled like a cloud upon his so amiable countenance within a few minutes of arrival?

Which of the hotels patronised by the British contingent would take the prize for late—or perhaps we should say early—hours?

Whether, since the "semaine anglaise" has approximated French week-end arrangements very nearly to our own, Saturday afternoon is really a wise time to choose for works visits?

* * *

A good deal of interest has been aroused, in these days when Manchester and others of our big cities are thinking of emulating London's tubes, by the Kearney High-Speed Tube Railway, with its promise of simplifying the traffic problem. Its characteristic is that the line comes to the surface at every station, and attains a high speed, dropping by a gradient of 1 in 7 to a depth of 100 ft. in a little over 200 yards. The trains will run on a single rail with an overhead rail for security, and double platforms will enable considerable time economies to be effected at the stations. From the point of view of the passengers' comfort there is everything to be said for the new scheme—fresh air will be plentiful, as the train will carry it from each station through the tube; we are promised that jolting and swaying will disappear, and the stations are to be on or near the surface. . . .

* * *

Readers who noticed a recent reference to the topic of rationalisation in these pages will have been interested to note the attention given to the subject as the result of a Paper read to the British Association by Prof. D. H. MacGregor. He dealt with one specific side of the question only, namely, that of large-scale industrial organisation—trusts and combines and their like as a means to greater efficiency and productivity in industry, and so forth. It appears that the newly-hatched term rationalisation is to serve a sort of omnibus purpose, and to cover any aspect of the improvement or anticipated improvement of industrial conditions and prospects, from no matter what point of view.

* * *

A FEW FOUNDRY PROVERBS.

All is not plumbago that's black.

A core in the mould is worth two in the stove.

Many hands make a heavy wages bill.

Too many cupolamen spoil the melt.

It is a wise moulder that knows his own casting.

What the inspector's eye doesn't see his heart doesn't grieve.

MARKSMAN.

Education and Industry.

On Monday, September 5, Section L (Education) of the British Association, discussed the association between education and industry. The Duchess of Atholl, M.P. (President of the Section), was in the chair.

MR. T. WICKHAM MURRAY (Secretary of the Association of Teachers in Technical Institutes), in the course of a paper on "New Outlooks and Tendencies," said that to-day the technical colleges provided the best link between education and industry. Almost everybody was convinced of the need for a closer liaison between the two for the benefit of the large proportion of the population who sought a living in industry and for the improvement of industry itself, but, unfortunately, there was as yet no adequate national policy under which the two could be brought together for their mutual benefit. Such a policy could not be formulated without a revision of some of those ideas which at present make up our educational philosophy.

MR. E. WALLS (of Messrs. Lever Bros.) discussed the educational needs of industry, and pointed out that 97½ per cent. of their pupils entered industry in some form or another, and educational plans should have the working life of the pupil in mind from start to finish. Stressing the need for greater co-operation between the schoolmaster and the employer, he said that industrialists were not alone to blame for the slowness of the forging of the link between industry and education; sometimes it seemed that the educationist had worked out his plans in this direction in the remote atmosphere of a vacuum.

"Foundry Trade Journal" Receives Award.

The Committee of the International Foundry Trade Exhibition has awarded to the "Foundry Trade Journal" a *Grand Prix*. It is pleasing to record that, despite language difficulties, the contents of the British "Foundry Trade Journal" are appreciated internationally. It is a compliment which will appeal to the whole of the British foundry industry.

MR. J. H. EVERETT (Leeds Technical College) dealt with the technical colleges and their courses and problems. The technical schools, he said, were really out to supply the requirements of industry, and not to sit in academic seclusion and do whatever they thought was right. Their aim was to train young people for their work in life; not necessarily to give skill, but rather to teach, by practical methods, the principles of the trade in which the apprentice was employed; to give adaptability, so that the apprentice could become a fully competent worker or craftsman. At the same time, technical education could have some cultural value.

DR. H. SCHOFIELD, in the course of a paper on "Engineering Training and Production," said that although the subject of training the engineer was one full of controversy which did not apparently grow any less as experience proceeded, there was yet one point upon which they had almost complete unanimity, namely, that somewhere in the training of the engineer some time must be spent in actual practical experience on productive output. This might precede or follow training at a University or higher technical college, according to the views held by those responsible for placing students in such institutions. There were difficulties whichever way the course was taken, and it was in an endeavour to get over these difficulties that the scheme of training now in progress at Loughborough College was founded.

For an all-round engineer there were three aspects of training, each of which was equally important. These were (1) its mathematical and physical side; (2) the question of management; and (3) the art of selling, distributing and of obtaining a market. The so-called engineering workshops in our larger technical institutions tended to become laboratories rather than workshops in the real sense of the term. Various methods of training had been introduced from time to time to deal with these difficulties. The Faraday House system embodied a very good admixture of the theoretical and the commercially practical; the works' productive "bays" in large firms, such as the British Thomson-Houston Company, Limited, of Rugby, and Messrs. W. H. Allen & Company, of Bedford, gave an excellent method of keeping the student in touch with production during his years of training; the experiments in America, at Worcester and Cincinnati, were also mentioned as giving a successful method of tackling this problem.

MR. A. P. M. FLEMING said that the portion of the subject assigned to him was to indicate how industrial firms themselves had attempted to provide suitable educational facilities for their workers. The attempts that firms had made to provide educational facilities of a more or less conventional type had, perhaps, led many who were not intimately associated with industry to form an entirely wrong conception of industrial educational needs; and, more particularly, of what those responsible for the conduct of industry believed to be its educational needs. He did not intend to touch upon the more conventional facilities, but rather to indicate those which did not fall directly within the recognised scope of education, whereas industrially they were educational efforts of the most vital kind, and applied equally to all types of workers, whether manual or mental.

The fundamental factor in industry was personnel, and the educational needs of personnel—industrially and individually—were to fit the worker for his environment whatever it might be. Industrial environment was continually changing, and conditions at the present time called for educational efforts which would produce an appreciation of the need, to the community, for intensive production; the ability to work effectively in a "team"; and to exercise independent judgment based on an accurate appreciation of facts; a spirit of fairness towards one's fellows; an instinctive desire to improve the means of productive effort in the service of the community; and all the other attributes that went to the making of a good citizen. While it was recognised that these qualities, which were essential to fitting a worker for his environment, could, in a general way, be developed through the more conventional educational facilities, the need for the exercise of them could not be fully appreciated by the juvenile until he entered his working environment, so that it was not until then that the best opportunities for such development occurred. To some extent organisations of the type represented by the boy scouts did much to fit the young worker for his industrial environment, but something much more intimately associated with his work was needed.

The author proposed to outline the types of organisations that existed in some of the large industrial concerns in which the juvenile workers were not only given training facilities which enabled them to follow effectively their own particular trade or vocation, but which provided the means for training in those aspects of industrial life that involved relationships with their fellows—whether in work, play, or in the general communal relations that existed between all sections and classes of workers associated together for industrial production.

Facilities for continuing this form of education in adult years were needed, and the most satisfactory were those which arose from the outworkings of societies and institutions which were identified with a man's work, or with the welfare of himself and his fellows. Thus, in all the healthy industrial concerns in which sports and general and social activities of every kind were being pursued actively, the real education of fitting a man for his environment was going forward effectively.

To gauge the importance of this type of education, one must bear in mind that in a country like Great Britain, industry was a fundamental necessity to the entire nation, and everything that operated against national prosperity eventually diminished the well-being of every individual. One of the most lamentable features operating against national prosperity was the unrest and want of agreement that existed between employees and the management of industry. An analysis of conditions showed that many of the factors referred to were involved, and it would seem that the only way of satisfying the educational requirements they represented lay in making the very best and fullest use of the experience of the worker in his particular sphere.

This "non-conventional" type of education must necessarily be closely linked up with the more conventional training of the worker for his job, and in the general, scientific, and economic principles underlying it. In so far as employment was concerned, it should aim at off-setting the general tendency to "safety first" in any job and create the outlook that industry had all the attractions of adventure. The instruction in economics should enable the worker to appreciate the various factors that governed raw-material supply, and should enable him to exercise judgment as to the possibility offered to him by employment overseas in the development of the vast field of undeveloped resources that was needed to feed the fast developing manufacturing resources of the home country.

XUM

Electric Power in the Foundry.—III.

By "KILOWATT."

In our last article on this subject we dealt with the electrical equipment of cranes in the foundry. Within this category of electrically-operated handling appliances we must include the lifting magnet for both external and internal use. This apparatus forms one of the most valuable combinations for economising time and labour in the difficult work of lifting and conveying of all classes of iron and steel materials. No time is required for adjusting hoisting tackle to the material to be moved, all that is necessary being the lowering of the magnet into the material, switching on the current, and transporting the magnet with the load to the desired point. These magnets are made in various shapes according to the class of material to be handled. For example, for lifting pig- and scrap-iron and large solid matters a circular magnet is used, while for handling long plates two or more of these magnets may be used, spaced on a beam slung from the crane hook. For such material as rails, blooms, ingots, and so on, a series of two or three rectangular or oval magnets on a beam may be adopted.

The carrying capacity of a lifting magnet depends on the shape and the nature of the material to be handled and the intimacy of contact with the pole pieces. For example, an ordinary circular magnet of about 5 ft. diameter is capable of lifting a 5-in. plate weighing about 30 tons, but it will only attract about 0.7 to 0.85 ton of cast-iron scrap, while for bulky steel turnings the carrying power will sink even to a third of a ton. This is explained by the fact that a solid mass of steel or iron with a surface affording a good magnetic contact offers the least resistance to the magnetic flow. On the other hand, a load comprising of loose scrap frequently forming a comparatively small surface of contact with the magnetic poles offers much greater resistance.

The modern lifting magnet consists of a case or frame of high permeability steel, the coil shield or bumping plate on the underside of the magnet being of manganese steel, which is non-magnetic. The coil is arranged with "locked" winding, preventing the possibility of any individual turn getting out of place. The insulation of this coil is of great importance, and the whole is impregnated under pressure with a special insulating compound, any moisture being extracted by means of a vacuum pump with the magnet hot, previous to allowing the compound to flow.

Substantial and properly designed switching device is necessary for controlling the current, as the high inductance draws an excessive arc on the switch point which would quickly destroy an ordinary switch. The controller for switching on these magnets therefore usually takes the form of a master drum operating a magnetic switch equipped with powerful blow-out coils, while another method of control takes the form of the contactor type.

Owing to the temperatures obtained in the operation of the magnet being high, mica and asbestos are used as insulating materials.

Liting magnets are only constructed for use with direct current, so that where the supply to the foundry is on the alternating current system it becomes necessary to convert it to D.C. through a motor generator set. A desirable voltage is 220, but there are magnets successfully operating on a 500-volt circuit. Current is conveyed to the magnets through a twin flexible cable, which coils up or pays out as the crane hook is raised or lowered. For this purpose a drum is carried on the crane, slip rings and brushes being provided on the drum to pass current from the fixed to the revolving parts.

Several special types of lifting magnets have been designed fitted with a safety device to hold the load in the event of the main current supply failing. This device consists of one set of accumulators connected up to two automatic switches carried on the top of the magnet frame in such a manner that should anything go wrong with the main current the accumulators are instantly and automatically connected across the magnet winding. A special switch in the driver's cage enables the driver to put the accumulators on charge each time the magnet makes a lift, and to disconnect the same when it is necessary for the magnet to release its hold. It is impossible for the accumulators to come into operation across the magnet so long as there is the main current on the magnet-feeding wires, and the magnet can only be made to loose the load at the will of the crane driver.

In some of the large, modern foundries, lifting magnets are used for quite a number of interior operations, and in such a capacity their effect is very important and contributes directly to two results, increasing production and decreasing labour charge without proportionally increasing equipment.

In a certain foundry where a magnet is largely used in interior work, a description of its various operations will probably be of interest. After the castings have been poured they are shaken out by two men who first lift off the cast steel cope flasks. These are then stacked on edge, side by side, between the rows of moulds. The crane then comes along with a magnet, picks up these cope flasks, generally getting four or five to a lift, and sometimes more, and stacks them in a pile at one side of the moulding floor.

The castings, which in this particular foundry, are not very large, are then dragged from the sand by means of a hook and are tipped into piles which include several castings. These piles are picked up with the magnet, carried to the end of the building and dumped at a point where the castings are rough-cleaned and the risers broken off. The drag flasks then are picked up by the magnet and handled the same way as the cope flasks.

For the next operation the magnet is lowered to within a few inches of the sand and is slowly moved along horizontally, gathering up all the small pieces of iron which have been left in the sand. This use of the magnet is so effective in its cleaning that the sand is seldom screened to remove the iron, nails, etc.

The number of workers required for cleaning up the floor has been conspicuously reduced, only about three men being required to clean up the entire floor of this rather large foundry.

This magnet also is used for handling such equipment as steel boxes or buckets which are used for conveying sand from one point to another, as the crane operator can make better time handling these with the magnet than he could if he had to wait for a man to fasten the crane hook on the article to be moved.

Another interesting use of the magnet is for filling the charging boxes for the open-hearth steel furnaces.

The combined economies of these operations are large. The number of workers is reduced, and the speed of producing castings materially increased because instead of waiting for the castings to cool off they can be handled while they are hot.

Canadian Steel Ingots and Castings

Production of steel ingots and castings in Canada during July reflected the lower output of pig-iron by falling to 55,250 tons, a decline of 8 per cent. from the 59,940 tons of June, which in turn was 39 per cent. under the 96,711 tons of May. In July, 1926, production amounted to 64,847 tons. Compared with the preceding month, production in July of this year showed declines in steel ingots, and direct steel castings; ingots dropped to 52,776 tons from 55,443 tons, and castings to 2,474 tons from 4,497 tons.

For the first seven months of the year production of steel ingots and castings totalled 542,560 tons, a gain of 9 per cent. over the 496,031 tons for the corresponding period of last year and 22 per cent. over the 446,168 tons made during first seven months of 1925. This year's output included 515,169 tons of steel ingots and 27,391 tons of direct steel castings. All of the ingots and 13,585 tons of castings were made in basic open hearth furnaces, 1,319 tons of castings were cast direct from converters and 12,487 tons of castings were made in electric furnaces.

The Constitution of Silicon-Carbon-Iron Alloys and a New Theory of the Cast Irons.*

By Professor D. Hanson, D.Sc. (Birmingham).

Slightly Abbreviated.

The constitution of the carbon steels, and its relation to their behaviour during casting, annealing, and heat treatment, is well understood, and the metallurgy of steel now rests on a very substantial scientific foundation. In the case of the other important series of iron-carbon alloys, known as the cast irons, the position is not so satisfactory. These materials are more complicated, both in regard to structure and composition, than are the steels, and although numerous investigations have given a large amount of information about them, a satisfactory comprehensive theory of the cast irons has not yet been evolved. Structurally the cast irons differ essentially from the steels in that the carbon can exist, and usually does exist, in two forms, iron carbide and graphite, and the main problem requiring solution is the definition and explanation of the relations between these two forms of carbon in the alloys. The theories which have been advanced, of which the most generally favoured is the "double-diagram theory," are admittedly incomplete and unsatisfactory.

Cast iron is by no means a simple alloy of iron and carbon; it contains considerable amounts of other elements—silicon, phosphorus, sulphur, and manganese—each of which is known to have an important influence on the alloy. The Cast Iron Research Association, recognising the importance of a fuller knowledge of the influence of these elements in cast iron, has initiated a series of researches on the ternary alloys of iron and carbon at the National Physical Laboratory, under the general supervision of Dr. W. Rosenhain, F.R.S. The first of these investigations—into the alloys of iron and carbon with silicon—was entrusted to the author, and the results so far obtained are now described, with the kind permission of the Cast Iron Research Association.

Experimental Details.

The experiments have had as their object the determination of the constitution of pure silicon-carbon-iron alloys, over the range of composition 0 to 2 per cent. silicon, 0 to 4 per cent. carbon.

Preparation of Alloys.—The alloys were made from electrolytic iron, pure silicon, and Acheson graphite. These are pure materials, only traces of any impurity being present, except oxygen in the electrolytic iron, which was reduced and removed during the preparation of the alloys. Chemical analyses are given in Table I.

TABLE I.—*Analyses of Materials.*

Material.	Fe. Per cent.	Si. Per cent.	C. Per cent.	All other impurities.
Electrolytic iron	99.79	—	0.006	0.004
Silicon	0.04	99.8	—	0.10
Graphite ..	Trace	Traces	99.9	0.1

In the electrolytic iron 0.2 per cent. of oxygen was present, with traces of copper.

In the silicon 0.03 per cent. of Al. and 0.024 of Ca. were present.

To simplify the process of alloying, two stock alloys were made:—(1) A 20 per cent. silicon-iron alloy (composition by analysis, 22.86 per cent. silicon), made by melting together silicon and iron in a crucible of fused magnesite in a high-frequency induction furnace, a nitrogen atmosphere being employed. (2) A high-carbon iron alloy, with a little silicon added to ensure its remaining grey, in which form it could readily be cut for weighing out. It was prepared as in the case of the silicon alloy, except that a crucible of Acheson graphite was used, the iron being allowed to dissolve as much carbon as possible. The chemical analysis of this stock alloy was—silicon 0.93, carbon 6.83, and iron 92.20 per cent. A series of eighteen alloys, containing 0 to 2 per cent. silicon and 0 to 4 per cent. carbon, was made, using the stock alloys. The materials were carefully packed in a crucible of fused magnesite and placed in a high-frequency furnace; the furnace was evacuated to a pressure of about 1 mm. mercury gauge, which was maintained during melting. A graphite lid on the crucible was very effective in preventing "bridging" or "scaffolding" of the melt, and did not increase the carbon content.

When first melted the alloy bubbled vigorously, owing to reaction between the oxygen in the iron and the carbon. The melt was kept liquid until no more gas bubbles were given off (which was ascertained by looking through a window in the top of the furnace), and the alloy was then cooled in the furnace tube. The ingots, which were generally sound, were cleaned and weighed, the average loss during melting, from various causes, being 1 to 2 per cent. About 150 grm. of each composition was made.

Cooling Curves.—Cooling curves were obtained by remelting 40 to 50 grm. of alloy in a crucible of fused alumina; a carbon-ring furnace was used, into which a stream of nitrogen was passed. The atmosphere inside such a furnace is very harmful to platinum thermocouples, and special precautions must be taken if reliable temperature readings are to be obtained. In the present instance the crucible was contained in a glazed muffle, closed at one end, which fitted into the tube of the furnace. A 5 per cent./20 per cent. platinum-rhodium thermocouple was used, it having been found that this combination, which is only slightly less sensitive than the standard 0/10 per cent. thermocouple, deteriorates much less rapidly in reducing atmospheres. The thermocouple was encased in a thin-walled silica sheath, closed at one end, which was lowered into the molten metal. Silica becomes very soft at the high temperatures used, and the sheaths would not support their own weight if allowed to rest on the bottom of the crucible; they were therefore supported from the cold end in such a manner that the bottom end of the sheath and the junction of the couple did not quite reach the bottom of the crucible. The sheath was maintained centrally in the crucible, and was prevented from warping in the hot zone by passing it through a central hole in a very deep crucible lid. The thermocouple was calibrated frequently by determining the melting point of pure iron, and the error was seldom more than 5 deg. C. at 1,500 deg. C.

TABLE II.—*Arrest Points and Composition of Alloys.*

Alloy.	Freez-point. Deg. C	Eutectic point. Deg. C.	A4 Deg. C.	A3 or Ac. Deg. C.	A1 Deg C.	Composition. Carbon. Per cent.	Composition. Silicon. Per cent.
SC2	1,507	—	1,476	754	632	0.31	0.48
SC3	1,503	—	1,457	738	686	0.36	0.93
SC4	1,481	—	1,433	760	686	0.33	1.89
SC5	1,514	—	1,457	795	–	0.18	0.44
SC6	1,509	—	1,457	774	680	0.12	1.04
SC7	1,453	—	1,419	–	714	0.66	1.88
SC8	1,438	—	—	–	694	1.08	0.40
SC9	1,453	—	—	754	694	0.82	0.95
SC10	1,427	—	—	–	731	1.00	1.97
SC11	1,390	1,100(?)	1,354(?)	982	708	1.88	0.33
SC12	1,419	—	1,346(?)	(?)	725	1.41	0.79
SC13	1,417	1,188	—	989	760	1.39	1.77
SC14	1,285	1,115	—	–	709	2.82	0.39
SC15	1,306	1,135	—	–	725	2.70	0.89
SC16	1,276	1,140	—	–	754	2.73	1.90
SC17	1,190	1,105	—	–	716	3.61	0.39
SC18	1,194	1,145	—	–	725	3.55	0.83
SC19	1,200	1,131	—	–	731	3.21	1.88

The A2 point appeared in the SC2 alloy only, at 667 deg. C.

* A Paper read before the Glasgow Meeting of the Iron and Steel Institute.

Inverse rate curves were taken on a Rosenhain plotting chronograph; the arrest points are tabulated in Table II, and plotted in Figs. 1, 2 and 3.

A separate chemical analysis was made of each cooling-curve ingot. Brinell hardness measurements were also made on each ingot (Table III).

Sections through the ingots were polished and examined microscopically; a representative series of micrographs is shown in Figs. 17 to 25.

Heat Treatment of Alloys.—A consideration of the microstructures of the alloys, in relation to the cooling curves obtained, shows quite clearly that equilibrium was not obtained in the cooling-curve ingots. A series of heat-treatment experiments was therefore undertaken with a view to elucidating the equilibrium structures of the alloys. In view of the high temperatures involved in work of this kind, and of the long periods of heating that are necessary, special precautions were taken to avoid oxidation of the small specimens necessarily employed.

In all instances specimens were annealed for a considerable time at about 1,150 deg. C., in order to obtain equilibrium at that temperature, and were then cooled very slowly to successive lower temperatures, from which they were quenched, and examined under the microscope. The furnace was controlled throughout, both during heating at a constant temperature and during the slow-cooling experiments, by means of a thermostat.

Small specimens cut from the original ingots were treated several at a time. The period of heating at the high temperature varied from several hours to two days, and the rates of cooling were usually of the order of 100 to 200 deg. C. per day. Specimens were usually held for some time at a constant temperature before being quenched in water. The total time taken for any experiment was usually about one week.

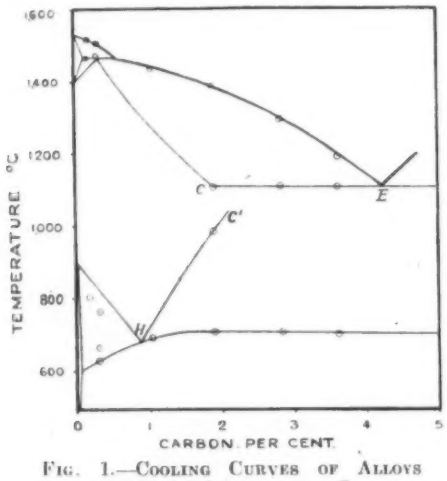


FIG. 1.—COOLING CURVES OF ALLOYS CONTAINING 0.4 PER CENT. SI.

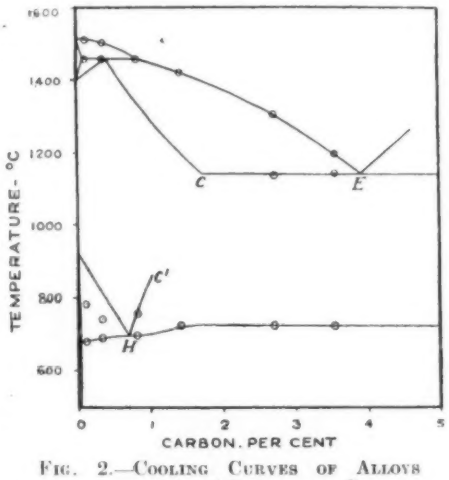


FIG. 2.—COOLING CURVES OF ALLOYS CONTAINING 0.9 PER CENT. SI.

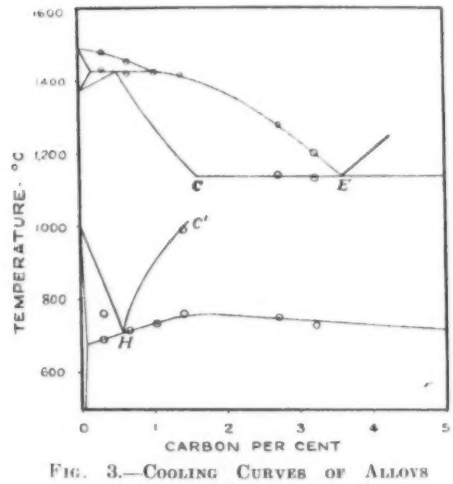


FIG. 3.—COOLING CURVES OF ALLOYS CONTAINING 1.9 PER CENT. SI.

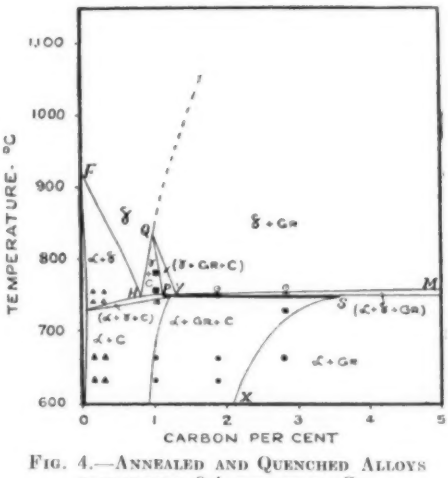


FIG. 4.—ANNEALED AND QUENCHED ALLOYS CONTAINING 0.4 PER CENT. SI.

TABLE III.—*Brinell Hardness Numbers (Cooling-Curve Ingots).*

Constant silicon. 0.4 per cent.		Constant silicon. 0.9 per cent.		Constant silicon. 1.9 per cent.	
Alloy.	Brinell No.	Alloy.	Brinell No.	Alloy.	Brinell No.
SC5	135	SC6	156	SC7	227
SC8	230	SC9	242	SC10	261
SC11	283	SC12	260	SC13	266
SC14	224	SC15	246	SC16	213
SC17	—	SC18	153	SC19	171

(Details of the various alloys, their heat treatment and the structures observed, are given in an Appendix to the Paper, and are represented micrographically in Figs. 26 to 40.)

None of the specimens showed any signs of oxidation after heat treatment, but some exhibited a curious feature which necessitated the use of new specimens for each treatment. In certain instances it was observed that the interior of the specimen appeared to have been decarburised; it was then found that the surface of such specimens was almost covered with a number of small black nodules, which, upon investigation, were found to be graphite. This migration and precipitation of graphite on the surface was taken into consideration when dealing with the microstructure of the alloys concerned. It was thought that this phenomenon might be due to the presence of gas in the tube, and that the equilibrium of the system might be disturbed by the presence of this gas. Some check experiments were therefore made, in which the vacuum pump was kept running continuously, day and night, thus maintaining a high vacuum throughout the experiment. This treatment was successful in preventing the migra-

tion of graphite, but the constitution of the alloys did not appear to differ in the two cases.

In order to avoid possible errors due to surface effects, practically all specimens were cut through the middle, the cut surfaces being polished; in any case in which a structure was considered to be doubtful repeat heat treatments were made.

Discussion of Results.

Cooling Curves.—From the cooling curves it is possible to construct diagrams indicating the transformations occurring in three series containing 0.4, 0.9, and 1.9 per cent. of silicon, and such diagrams are shown in Figs. 1, 2, and 3 respectively.

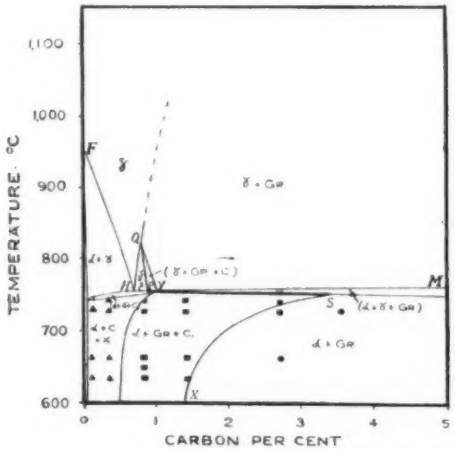


FIG. 5.—ANNEALED AND QUENCHED ALLOYS CONTAINING 0.9 PER CENT. SI.

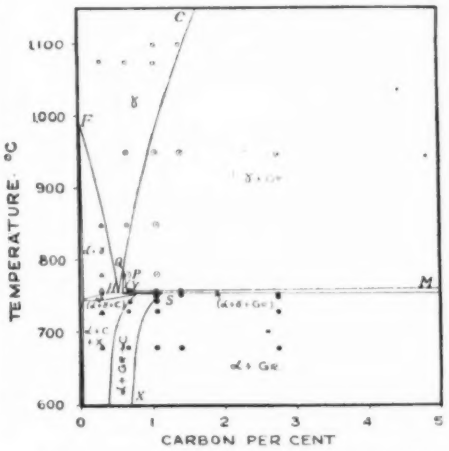


FIG. 6.—ANNEALED AND QUENCHED ALLOYS CONTAINING 1.9 PER CENT. SI.

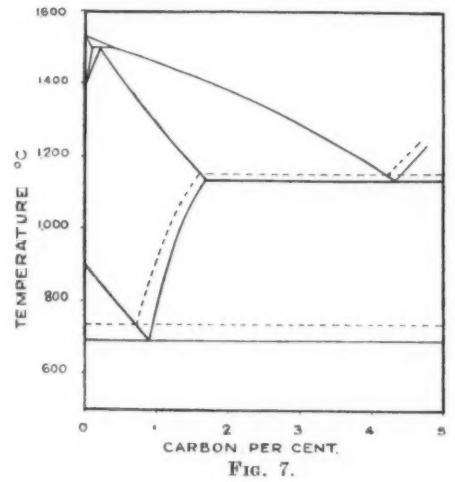


FIG. 7.

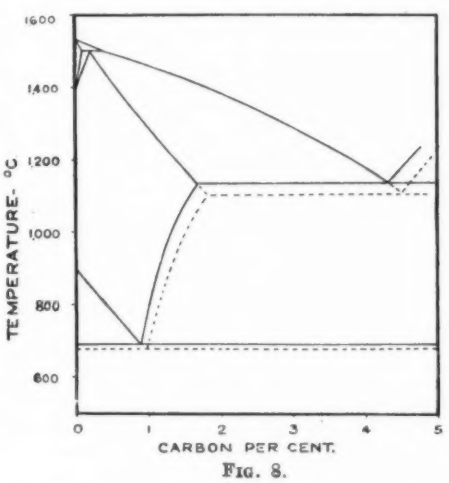


FIG. 8.

The liquidus curves are well defined, as is also the arrest due to the transformation of δ- to γ-iron. The temperature of this transformation is higher than in pure iron, but lower than in pure iron-carbon alloys, and extends over a wider range of carbon concentrations as the silicon content is increased.

The eutectic arrest *CE*, which is well defined, is clearly due to the austenite-graphite eutectic; this is definitely established by the microstructures; Fig. 26, in particular, shows clearly primary austenite grains embedded in a very fine matrix of austenite-graphite eutectic. This structure is similar to that obtained by Piwowarski in his superheated cast irons. No evidence was obtained of the prior formation of the austenite-cementite eutectic; there was but one heat evolution on the cooling curves. If graphite were formed only from cementite, two heat arrests should be observed, one corresponding to the formation of the austenite-cementite eutectic, and the second to the decomposition of the carbide. The possibility of graphite forming through cementite is not denied, since under certain conditions it has been proved to occur, but in the present experiments there appears to be no doubt that graphite separated direct from the liquid as one of the constituents of the eutectic.

The eutectic point E, shown in Figs. 1, 2 and 3, occurs at lower concentrations of carbon as the silicon is increased. It occurs at 4.2 per cent. carbon with 0.4 per cent. silicon; at about 3.8 per cent. carbon with 0.9 per cent. silicon; and at 3.6 per cent. carbon with 1.9 per cent. silicon. Silicon has little effect on the eutectic temperature.

The solidification of the alloys investigated appears to take place by separation of austenite, or austenite and graphite, from the liquid (except where δ-iron is found), and the diagrams may therefore be regarded as representing the system iron-graphite.

The arrest points below the eutectic line, however, appear to correspond to the separation of iron and iron carbide. The microstructures appear to admit of no other conclusion. Specimens *SC* 2, 3, 4, 5, and 6 contain ferrite and pearlite, and the upper arrest point for each alloy must be due to ferrite formation, and the lower one to pearlite formation. The other alloys all contain a pearlite matrix, free ferrite being absent, as shown in Figs. 17 to 25. In many of these alloys pro-eutectoid cementite is present, and the arrest points in *SC* 9, 11, and 13 at 754 deg., 982 deg., and 989 deg. C. respectively are clearly due to cementite separation. This is illustrated by Fig. 18, in which the cementite needles are clearly seen embedded in a pearlite matrix. In alloys with high carbon contents pro-eutectoid cementite is not always clearly visible, and may not be formed.

It will be observed that the eutectoid point in the iron-cementite system occurs at a lower carbon content as the silicon is increased; the eutectoid temperature rises with increase of carbon when

the silicon remains constant, and with increase of silicon when the carbon is maintained constant.

It seems clear, then, that the diagrams of Figs. 1, 2, and 3 must be regarded as composite diagrams; that portion down to and including the eutectic represents an iron-graphite system, but at some temperature below the eutectic line the alloys undergo transformations according to the system iron-cementite For this reason the lower and upper parts of the diagrams have not been joined.

Heat-Treatment Experiments.—The experiments on heat-treated specimens were designed to investigate the region below the eutectic, and to determine, in particular, the reactions between graphite and cementite. The annealing periods used were long and the rates of cooling slow, while the experiments were all carried out *in vacuo* to avoid reactions due to oxygen (or CO and CO_2). The structures observed are therefore considered to represent closely the true equilibrium of the iron-carbon-silicon alloys.

The results are shown in Figs. 4, 5, and 6, in which the alloys examined, and the structures observed, are indicated. The evidence upon which the phase boundaries are fixed is therefore clear. The three constant-silicon diagrams present broadly the same features, and it will therefore be convenient to consider one in detail and subsequently to point out the small variations in the other two. Fig. 6, representing alloys containing 1.9 per cent. of silicon, has been most fully investigated and may be considered first. The line *CQ* represents the solubility of graphite in austenite, and is accurately fixed by the experimental data. It represents the temperatures and concentrations at which graphite separates from austenite on cooling. Comparison with Fig. 3 shows that it occurs at a higher temperature than *C'H* representing the separation of cementite, which is formed when the cooling rate is greater. In addition, the times of annealing and cooling in the heat-treatment experiments are such as to ensure a close approach to equilibrium, and it may therefore be assumed that the lines of Fig. 6 are equilibrium lines, and that graphite is the stable form of carbon in the region under consideration. Cementite is then only produced as a metastable phase when the rate of cooling is accelerated. Alloys containing more than 1 per cent. of carbon deposit graphite from austenite on cooling, until the line *PM* is reached. Figs. 29 and 32 afford evidence of the truth of this statement; they represent alloys *SC*7 and *SC*10, quenched from 780 deg. C. (just above *PM*), and consist of graphite and martensite (formed from austenite on quenching). In the 1.9 per cent. silicon alloys of high carbon content, therefore, graphite separates continuously from austenite from the eutectic to the eutectoid temperatures.

On cooling hyper-eutectoid alloys through the line *PM* a further change occurs, and ferrite appears in the specimens, probably accompanied by more graphite; immediately below *PM*, ferrite, graphite, and austenite co-exist, as shown in the diagrams, and illustrated in Fig. 33, which represents the same alloy as is shown in Fig. 32 (*SC*10) quenched from 765 deg. C.; the structure shows ferrite, graphite, and martensite (austenite). Fig. 37 shows ferrite, graphite, and martensite in *SC*13. The zone in which these three phases co-exist is, however, very narrow, and on further cooling martensite rapidly decomposes. At 750 deg. C. graphite, ferrite, and carbide (pearlite) co-exist, as shown in Fig. 34, while Fig. 35 shows the same alloy (*SC*10) quenched after slowly cooling to 730 deg. C., at which temperature only ferrite and graphite exist.

In hypo-eutectoid alloys ferrite separates from austenite: the line *FH* represents this separation. The exact position of this line is not fixed by these experiments, but the point *F* is fixed by the work of other investigators, and the general character of the line is doubtless correct. The existence of a ferrite-austenite structure below this line has been confirmed by these experiments, and is shown in the diagrams. The iron-carbide eutectoid in these alloys occurs over a range of temperature, as might be anticipated in a ternary system, and as confirmed by experiments on alloy *SC*4, indicated in the diagram, Fig. 6. Within this eutectoid range ferrite, cementite, and austenite can co-exist. Immediately below the eutectoid range the stable phases are ferrite (iron) and cementite: the cementite may, of course, form pearlite with a portion of the ferrite.

It is thus seen that in high-carbon alloys ferrite and graphite are the stable phases below the critical ranges, and that in low-carbon alloys ferrite and cementite are stable, but between these extremes there is a region, narrow in Fig. 6, in which ferrite, graphite, and cementite all exist together. The existence of such a field is theoretically essential if the relative stabilities of cementite and graphite are as described above, and the experimental confirmation of this field is very satisfactory. It may be illustrated by Fig. 31, showing alloy *SC*7 quenched from 752 deg. C., at which temperature it consists of ferrite, graphite and cementite (pearlite).

Figs. 4 and 5, representing alloys containing 0.4 and 0.9 per cent. silicon respectively, possess all the features shown in Fig. 6, and serve to confirm the theory that carbide and graphite can each be stable over certain ranges of composition, and can coexist over an intermediate range. Below the critical range, about 750 deg. C., the constitution is of the same type as that of Fig. 6, but above this range an important difference is to be observed, which still further confirms the theory. In Fig. 6 graphite is shown to be the stable form of carbon; but it is clear that if cementite is the stable variety in low-silicon iron-carbon alloys, a zone of composition and temperature must exist in which cementite separates direct from austenite and coexists with it. Evidence of such a zone is given in both Figs. 4 and 5. Alloys *SC*8 and *SC*9, containing approximately 1 per cent. of carbon with 0.4 and 0.9 per cent. of silicon respectively, deposit cementite directly from austenite, as shown on the diagrams; but alloy *SC*11, containing 2 per cent. of carbon with 0.4 per cent. of silicon, deposits graphite continuously while cooling through the austenitic range, as do other high-carbon alloys in both series. A zone of stability of carbide in contact with austenite has therefore been established. The case would be still stronger if a zone in which carbide + graphite + austenite could be established. That such a zone must exist cannot be doubted, but the evidence shows that in Figs. 4 and 5 it must be narrow, and must exist in alloys containing a carbon content somewhere between 1 and 1.8 per cent., the exact range not being indicated. Unfortunately, no alloys were available within this range, and its existence could not be verified experimentally. It has, however, been drawn in the diagram as a narrow zone *PQY*.

The point *Q*, whose existence is demonstrated, but whose position is not accurately fixed, marks the place on the carbon solubility curve above which carbon separates from solution as graphite, and below which it separates as cementite. It is, theoretically, a very important point, for if the conception of separate iron-graphite and iron-cementite systems be accepted, it marks the point of their intersection. Its existence, which the author considers to be proved by the facts now advanced, will be used to develop and test a new theory of ternary iron-carbon-silicon alloys, and to account for the constitution of the cast irons. The theory is applicable also to other ternary iron-carbon alloys containing graphite.

Below the eutectoid temperature within the field called ferrite + carbide certain unusual structures were observed which require further investigation. In some alloys another constituent was observed, which has been called "X." The characteristic appearance is shown in Figs. 27 and 28, representing *SC*4 and *SC*6 quenched from 730 deg. and 738 deg. C. respectively. In samples etched with 1 per cent. nitric acid in alcohol the constituent is indistinguishable from the carbide, except that it contains a large number of fine specks, which appear in unetched specimens and are probably graphite. In some cases, as in *SC*6, they exist outside the boundaries of the constituent, in the surrounding ferrite, as if decomposition into ferrite and graphite had taken place on the outside of the particle. They are found in low-carbon irons containing 1 per cent. or more of silicon. They have not been further investigated, but they are clearly of importance.

The constituent **X** differs from carbide in that it can be seen in unetched specimens (see Fig. 28), and is also attacked in a different manner

by sodium picrate, which blackens Fe_3C, but only stains the new constituent slightly (generally patchily). The existence of this new constituent does not affect the author's theory of carbon-graphite equilibrium.

The Equilibrium between Iron and Carbon.

It is well established that in certain ternary alloys, particularly those containing silicon, graphite can exist as a stable phase over a wide range of temperature and composition, and this has led to the suggestion that the iron-carbide phase is not necessarily stable even in pure iron-carbon alloys. Its occurrence over wide ranges of composition and its persistence under various forms of heat treatment, both in pure iron-carbon alloys and in cast irons, has led to the introduction of a number of equilibrium diagrams to account for the varying behaviour of these materials.

The most generally accepted diagrams are those consisting of a double-equilibrium diagram, in which the systems iron-carbide and iron-graphite are both represented. Certain investigators, notably Roozeboom and Benedicks, have suggested diagrams in which graphite is represented as a stable phase, and the lines referring to the graphite equilibrium are drawn at higher temperatures throughout than those representing the carbide equilibrium. On the other hand, Rosenhain has suggested a diagram in which carbide is represented as a stable phase and graphite as the unstable modification. None of these diagrams is complete in the sense required by the phase rule, and they are all alike in one respect, that only one form of carbon is represented as stable over all ranges of temperatures.

The two types of diagrams, drawn to be consistent with the phase rule and differing but little from those suggested by other investigators, are shown in Figs. 7 and 8. In Fig. 7 graphite is shown as the stable phase, and the graphite system is represented by dotted lines where it does not coincide with the carbide system. Fig. 8 represents the corresponding diagram in which the carbide system, represented by full lines, is stable. In Fig. 7 the graphite diagram is stable over all ranges and temperatures, and in Fig. 8 the carbide diagram is always the stable type.

Neither of these diagrams offers a satisfactory explanation of the phenomena connected with the behaviour of iron-carbon alloys, whether these be steels or cast irons. As a result of investigations

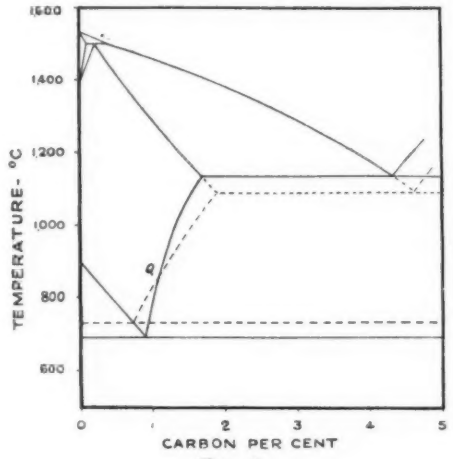


FIG. 9.

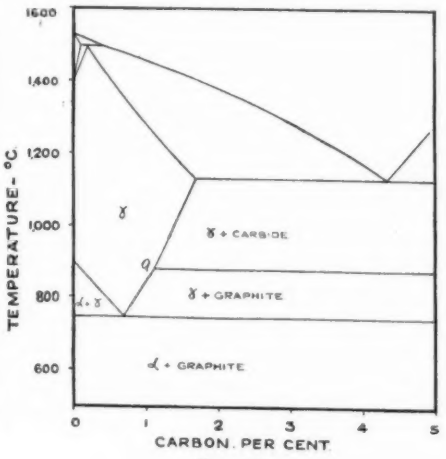


FIG. 10.

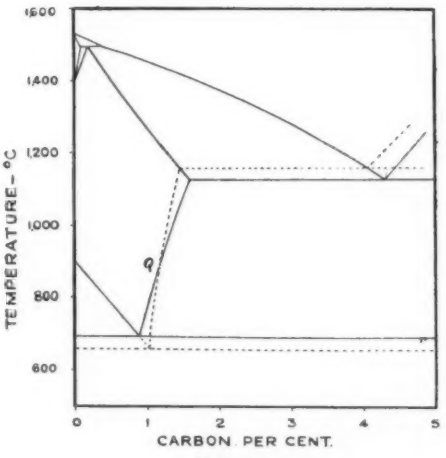


FIG. 11.

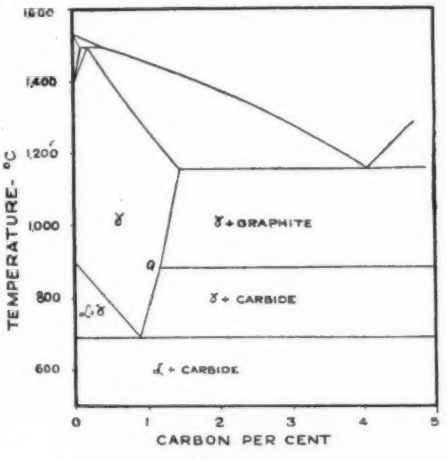


FIG. 12.

(described in this Paper) into the equilibrium of the ternary system iron-carbon-silicon, the author has been led to an examination of the consequences that would follow if the two diagrams representing graphite and carbide respectively overlapped instead of remaining always one above the other—that is, if at some temperature the system changed from one in which graphite is stable to one in which carbide is stable. Such a possibility is by no means inconceivable, and might, in a binary system, occur as a result of the alteration in one of the degrees of freedom (although there is no experimental evidence that such occurs), and in a ternary system such a change might well be induced by the presence of a third element. In this latter case, the diagrams representing the system would require modification in a manner that will be considered later, and it will be convenient to approach the question by assuming the possibility of such a change in a simple binary system.

Consider first of all the double diagram in which carbide is represented as the stable phase at high temperatures, but in which the graphite system becomes stable at lower temperatures, between the eutectic and eutectoid temperatures. Such a case may be represented as in Fig. 9, in which the two diagrams are shown, but in which the graphite

system crosses the carbide system at the temperature of the point Q. If now the stable reaction lines be picked out from this double diagram, and the necessary simple modifications necessary to preserve it as a phase diagram be made, the form shown in Fig. 10 is arrived at, in which the stable constituents in the various phase fields are indicated. This diagram differs from the ordinary iron-carbon equilibrium diagram in that graphite becomes the stable phase at the temperature Q, and the eutectoid, which now occurs at a rather higher temperature, consists of α-iron and graphite. The stable phases at temperatures below the eutectoid are everywhere α and graphite.

A similar method of attack in the case in which graphite is stable at the high temperature and carbide at lower temperatures is represented in Figs. 11 and 12, Fig. 11 representing the two diagrams superimposed on one another and crossing also at the point Q, and Fig. 12 representing the stable binary diagram deduced from these two forms.

It must be emphasised that these are hypothetical cases for which there is no evidence in the pure binary iron-carbon system, for there is nothing to suggest that any probable modification in the degrees of freedom of the system would produce such a result. On the other hand, a modification of this kind is not only conceivable, but, as will be shown, is highly probable when another element is added to the system, but the diagrams representing such a case will require modification in order to make them consistent with the known laws of ternary equilibria. This modification is quite simple in principle, although it may lead to much more complicated forms of diagram. When the third element is present the horizontal lines in the binary system, representing the boundaries between phase fields containing two constituents, must be replaced by zones of a definite width, and the transformation represented by those zones will not in general, in the ternary system, occur at fixed temperatures. The temperature range will vary with the composition of the alloy; in other words, the lines bounding these zones need not be horizontal on the diagram.

Such modification might take the simple forms shown in Fig. 13, in which the diagram would be relatively little altered; but, in general, the zones starting from the points E, Q and R will meet one another at a point which will depend on the manner in which the third element modifies the system, and it will be interesting to examine the consequences which will follow in such cases. Dealing first of all with the modifications of Fig. 13, two probable modifications at once suggest themselves, one corresponding to the case in which the field starting from the point Q falls and meets the field representing the eutectoid, starting from the point R. The type of diagram produced in this case is shown in Fig. 14, which then becomes, of course, a section through a ternary model representing the system iron-carbon-Y, where Y is the third element.* In Fig. 14 it will be observed that a new phase field is introduced, additional to the narrow zones resulting from the widening of the horizontal lines of the binary diagram. This new field, N_1NVV_1, represents a region of composition in which the three phases α-iron, carbide and graphite can coexist, such a phase field being clearly possible in a ternary system, although inadmissible in a binary system.

The second case, in which the field starting from the point Q rises and meets the binary eutectic zone starting from the point E, is represented in Fig. 15; in general type it is somewhat similar to Fig. 14, and two new ternary fields $TWXV$ and N_1NVV_1, should be noted, the first representing the coexistence of γ-iron, carbide and graphite, and the second the coexistence of α, carbide and graphite. In both Figs. 14 and 15 it will be observed that a region representing α + carbide occurs at low carbon concentrations and is succeeded by a field representing α + carbide + graphite. In Fig. 14 this second field is succeeded by a third, at a higher carbon concentration, in which α + graphite coexist, while in Fig. 15 these two fields are succeeded by one in which carbide + graphite coexist.

An exactly similar pair of diagrams can be developed in the same way from Fig. 10, but they will differ from Figs. 14 and 15 simply in that graphite must be substituted for carbide and carbide for graphite, so that below the eutectoid region alloys corresponding to these systems would consist of α + graphite in the region of lowest carbon content, α + carbide + graphite in the intermediate zone and α + carbide or carbide + graphite in regions of high carbon content. Thus, from the simple assumption that the carbide and graphite systems intersect in a three-component system, four types of diagram representing theoretical relationships between the different phases may be developed, and each of these four theoretically possible diagrams differs in some notable respect from all the others.

The above cases do not exhaust the possibilities, since slightly different diagrams would be given if the eutectic zone were raised or the eutectoid zone depressed by an increase of carbon. The modifications in such cases would be slight, and would not affect the argument developed above.

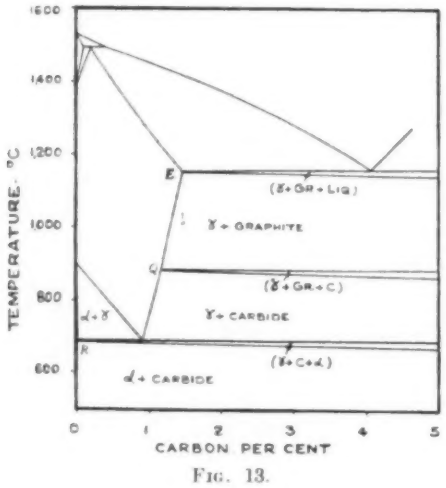


FIG. 13.

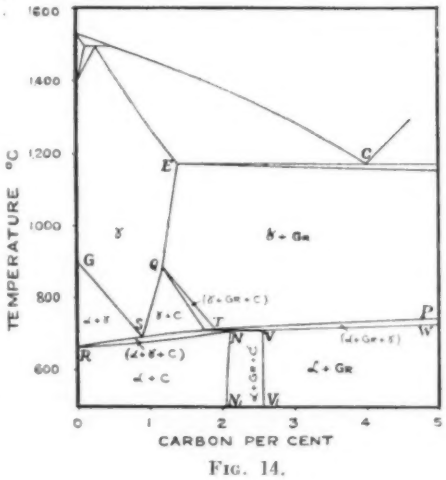


FIG. 14.

* It is further necessary to assume that the addition of Y introduces no new phases. This assumption is justified in most iron-carbon systems for small additions of an added element. New phases are not introduced when the added element dissolves in the iron or forms carbide isomorphous with iron carbide. When a new phase is introduced the theory will require modification within the range of existence of that phase.

(To be continued.)

SIR GEORGE HUNTER, chairman of Swan, Hunter & Wigham-Richardson, Limited, shipbuilders, will announce at the annual meeting of the company, in 1928, his retirement. It is understood he will be succeeded by Mr. J. E. Thirlaway, vice-chairman of the company. Sir George Hunter, who is in his 82nd year, will retain a seat on the board of directors.

Test Bars to Establish the Fluidity Qualities of Cast Iron.*

By C. Curry, Ardennes, France.

Among the most interesting problems which regular foundry practice brings up, the fluidity quality of the metal is among the ones that deserve quite particular attention. If, in fact, this quality of the metal is one of the fundamental ones in foundry work, the search for practical means that will aid in reducing the percentage of scrap castings seems no less interesting.

What is Fluidity?

We will accordingly define the fluidity or running qualities (life) as follows: *The aptitude of a liquid in a given condition to fill a mould prepared under determined conditions.* This quality depends on a good many factors, such as temperature, viscosity of liquid, nature of liquid, temperature of mould, weight, surface, superficial curvature of the castings, nature, dimensions and dispositions of the mould, conditions of surface, etc.

The knowledge of only one of these factors does not permit us by any means to determine the quality which it is desired to define. Thus, for instance, the temperature of an alloy is quite an insufficient indication for the foundryman; iron coming from a cupola may have a very high temperature and still possibly is not as liquid as another one having a lower temperature but of a totally different chemical composition.

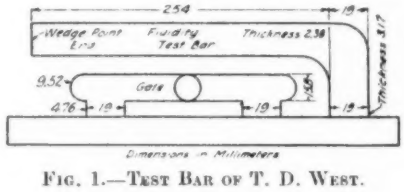


FIG. 1.—TEST BAR OF T. D. WEST.

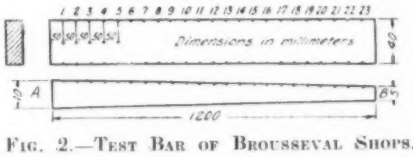


FIG. 2.—TEST BAR OF BROUSSEVAL SHOPS.

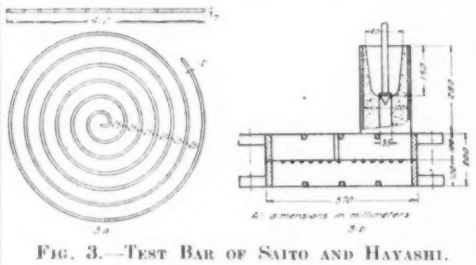


FIG. 3.—TEST BAR OF SAITO AND HAYASHI.

Accordingly it is of the highest importance for the foundryman to possess a simple and speedy means of investigating, that will permit him to act promptly on this point which is of vital importance.

Early Investigation.

The Paris Foundry High School† could not but feel interested in this problem, so this research was indicated to the students as likely to form the object of the personal work imposed on each of them, on account of its possibility of being treated scientifically. The result is the present experimental work, performed with the aid of suggestions given by Mr. E. Ronceray, curriculum director, and augmented by the result of the researches followed since then, which will be reviewed in the following portions of this Paper.

This problem, moreover, has for a long time constituted the object of intense work of eminent practical men. It seems that the first researches on the subject must be attributed to Thomas D. West, who, in 1898, made experiments as to running qualities by making up the test bar shown in Fig. 1. This test bar constitutes a first attempt, inadequately handled, but still interesting, especially if we consider the date when it was originated.

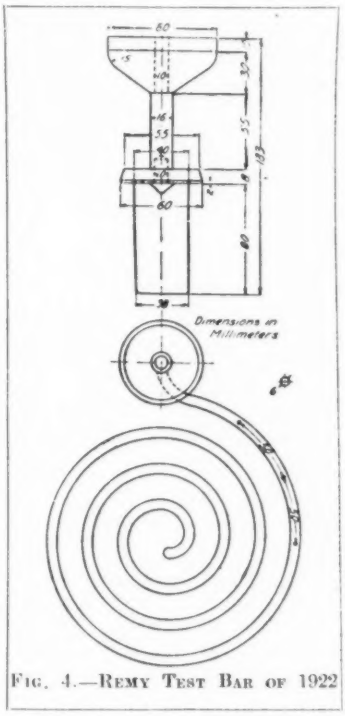


FIG. 4.—REMY TEST BAR OF 1922

The question was studied after West by several persons, and there can be mentioned the test bar of Mr. Ledebur (1904), which test bar, of 250 by 25 by 1.5 mm. (9.83 by 98 by 0.059 ins.), was run on one end, which largely resembles the foregoing one. The experiments of A. H. Sexton and J. S. G. Primrose (1911) were made with a thin test bar of the same kind of section (1 in. by $\frac{1}{16}$ in.), run also on one end.

In 1917 Dr. Richard Moldenke used a test bar in wedge shape, pointed at one end, and of a section of 1 in. by $1\frac{1}{2}$ in. at the other. It should also be noted that the Brousseval concern presented to the first International Foundrmen's Congress in 1923 a similar but very long test bar which is run on the flat (Fig. 2).

In 1919, two Japanese experimenters, Daikichi Saito and Kennosuke Hayashi,* originated a test bar of the following form:—"Instead of using a simple, straight rod as a pattern for making the mould, they used a spiral of the type shown in Fig. 3, respectively, in order to show up in a still more striking way the differences in fluidity between samples of different metals. The mould was provided with a pouring gate, and a riser at the centre. The pattern was embedded in sand so as to make a mould into which the metal could run."†

* A Paper presented on behalf of the Association Technique de Fonderie to the American Foundrymen's Association.

† Ecole Superieure de Fonderie, Paris.

* Proceedings of the College of Engineering, Kyoto Imperial University, II, 83, 1919, and IV, 165, 1924.

† "Fluidity of Cast Iron," a Paper presented by Professor C. H. Desch to the Sheffield Branch of the Institute of British Foundrymen, published by THE FOUNDRY TRADE JOURNAL on February 2, 1922.

In 1922, Mr. Remy, a malleable iron founder of Liège, Belgium, again took up this test bar, which he made in the following manner:—The spiral has a circular section of 6 mms., or 1.97 ins. The metal is poured in a basin placed on the side of the mould and runs into a reservoir located underneath where the cast iron runs down, through a hole of 5 mms. (0.197 ins.) diameter. The dimensions of the reservoir are established in such a way that the metal penetrates into the spiral only after the filling of the inlet basin and consequently with a constant speed (Fig. 4).

This test bar has seemed to the author to embody the most rational conception that has been reached; hence he has started from this with the intention of examining more especially the

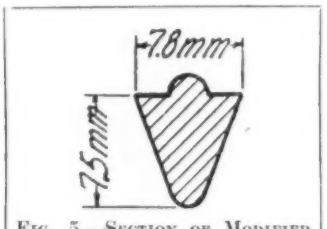


FIG. 5.—SECTION OF MODIFIED SPIRAL SHAPE.

influence of the mould itself and of its conditions on the results obtained.

Modified Test Bar.

In agreement with Mr. Remy and on the suggestion of Mr. Ronceray it seemed desirable to modify the section of the spirals which presented moulding difficulties, and to replace it by a section of triangular form with slight rounding at the parting. The dimensions have been calculated in such a way that the new section is essentially equal to the old one in order to maintain the same volume of delivery (Fig. 5).

The first tests run on identical moulds, which were rammed by a pressure moulding machine, using the same sand and poured as green sand moulds in a horizontal position, and poured from the same ladle of hot iron, have disclosed rather

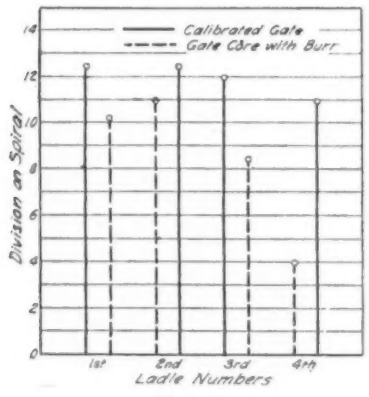


FIG. 6.

noticeable differences in the length of the test bars obtained, and accordingly it was concluded that the test bar was imperfect.

Successfully eliminating the different factors which were of a nature conducive to errors in the results, it can be stated that the least burr (fin) in the gate of the core, which gate has a diameter of only 5 mms. (0.197 ins.), and even simply a slight dropping of the sand from this core at the moment of casting, had the effect of modifying the results considerably. It has been found that for a gate section reduced from 5 to 4 mms. (0.197 to 0.157 ins.) the difference in the length of test bars was of an order of four divisions. With a considerable burr reducing by about one-half the section of gate the spiral ran out only two divisions, while the same metal run in a test bar with calibrated core reached 11 divisions. The chart, Fig. 6, reproduces the data obtained in the experiments. The irregular section of the gate of the core has accordingly a considerable influence on the result. It is shown later how this cause of imperfection was eliminated.

In tests which followed, with a view to looking into the other factors, the author therefore made it a point that the tap hole was as exactly dimensioned as possible. Having thus made the experimental conditions pretty well identical, he found the following to be established:—

(A) *Horizontal Position of the Mould.*

This factor is very important, a slight incline falsifying the results entirely. In a general way we have noticed that the inclination of the mould

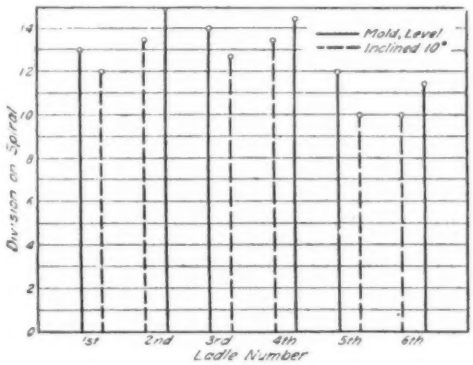


FIG. 7.

was to reduce the length of the spiral. This can readily be explained by the tendency which the metal has to drop to the lowest point and stay there (Fig. 7).

(B) *Humidity of Sand.*

This factor, curiously enough, does not seemingly interfere at all, even if the humidity is greatly changed. The author has run simultaneously moulds in a very dry sand, whose moisture content did not exceed 3 per cent., and moulds made with a sand with 7 per cent. moisture, and has obtained in the two cases substantially the same results. Further, by drying a mould with a welding lamp and running it against another one in moist sand, it was found that the

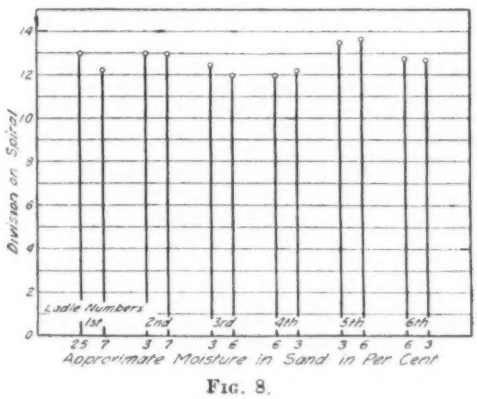


FIG. 8.

difference between the two test bars obtained would reach hardly one division (Fig. 8).

(C) *Influence of the Trapped Air at the Extremity of the Spiral.*

It was thought that the gases compressed at the end of the spiral at the moment of the run might oppose a certain resistance to the path of the metal. Experience has shown that this was not the case and that vent holes from 2 mms. up to 10 mms. (9.079 to 0.394 ins.) and beyond did not influence in any way the results.

These established facts suggested researches on two principal points as follows:—(1) Remedying, if possible, the cause of error arising from the difficulty of exact dimensioning of the core; and (2) doing away with, or at least decreasing, the influence of the inclination of the mould.

The solution of these problems was to be sought in two ways. For the first point, by finding

a way of regulating the speed of iron run through the section of the spiral and not through the section of the gate of the core, the latter serving the purpose of avoiding the dynamic effect of the stream of metal; for the second point, by placing the runner at the centre of the mould.

Final Test Bar Design.

For this purpose, and at the suggestion of Mr. Ronceray, the test bar was changed in the following manner:—The gate is placed in the centre of the spiral; the gate is provided with a filter core of a standard form with three filter holes of 8 mms. (0.315 in.) diameter, and the downgate has a section of 15 mms. (0.59 in.). The reservoir was reduced in part; it may be reduced still more, as will be shown later. In Fig. 9 is shown a sketch of the test bar thus changed.

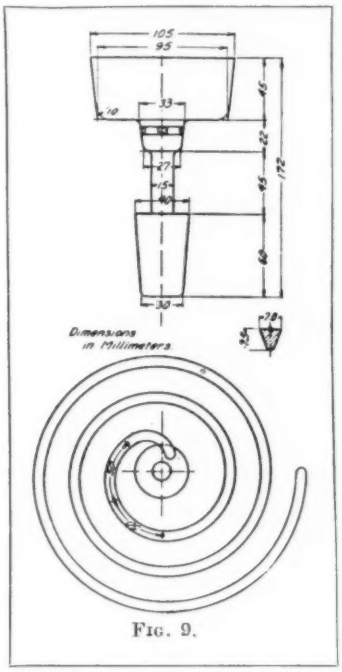


FIG. 9.

When the results of the larger delivery capacity of the gates and filter holes were compared with more sensitive gates when placed in identical conditions, the results remained essentially constant. It has, moreover, been noted that starting from a certain limit, the increase of section of the holes of the filter of running did not influence the results. This statement is based on experiments made with tests of filter cores with three holes and with two holes, for which the same lengths were obtained.

On the other hand, the rôle of the reservoir, which, in the foregoing test bar was to obviate the running of iron into the spiral before the complete filling up of the basin, had in the present case only the purpose of receiving the first lot of iron. The experiments made with reservoirs of varying capacity, moreover, clearly indicate that if the path of the metal increases slightly to the proportion in which the capacity of the reservoir increases, the results for one and the same approximate capacity remain constant, and it is possible to reduce the dimensions of the reservoir without inconvenience (Fig. 10).

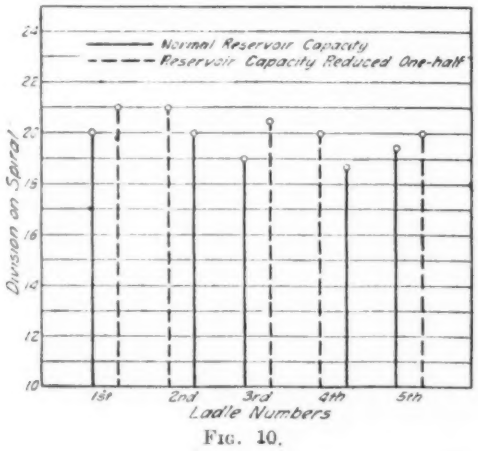


FIG. 10.

From the above experiment it can be concluded that the arrangements described permit the obtaining of results that can be compared without varying the factors foreign to the metal, except within limits practically easy to realise. It is sufficient for this purpose to make a mould in green sand under conditions that are very simple, and to run the iron through a core filter of standard design of three holes of 8 mms. (0.315 in.). This affords the advantage of eliminating to a considerable extent the cause of errors arising from a defect of inexact dimensioning of the filter core holes of 5 mms. (0.197 in.), and in the second place of obtaining with the same metal at the same temperature the largest length of spiral, and through this very fact a scale of comparison that can be more easily interpreted.

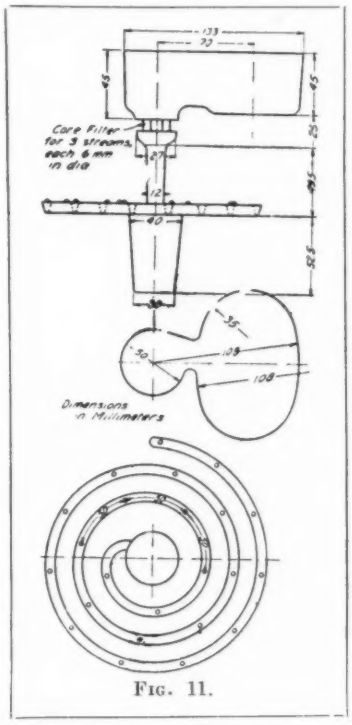


FIG. 11.

Later on it was found interesting to make a pouring basin, avoiding the direct pour on the filter core. The drawing (Fig. 11) shows the changed box and the apparatus as it is made up and employed at present.

Effect of Mould Linings.

The regular use of this test bar has permitted the establishment of quite unusually interesting observations. Thus, for instance, the linings of the mould play a very important part on the facility of filling. It has been found that moulds faced with graphite give a number of divisions very much higher than a mould of natural sand, and this has brought about in one foundry the elimination of numerous rejections by continuing the use of graphite, which was about to be discarded.

In malleable-iron foundries the moulders are often having arguments with the man in charge as to the quality and temperature of the metal supplied. In the author's foundry he is running chiefly very small castings, and the moulders are working on a piece-work basis. This test bar has become almost indispensable, not only to assure controlled running, but also to serve as arbitrator between the management and the workmen, this arbitrator permitting us definitely to establish the cause of wasters. In the manu-

facture of a special article in great numbers, for instance, the author was able to establish a scale of running qualities, in consequence of which he has almost entirely eliminated scrapped castings. A ladle of about 40 kilograms (88.2 lbs.) giving from 11 to 12 divisions to the test bar, permits one to run a series of moulds without misruns. On the other hand, if the same ladle gives about 10 divisions, it is necessary to pig the 8 to 10 kilograms (17.6 or 22 lbs.) from the bottom of the ladle in order to obviate the misrunning of the castings contained in the last moulds. Below eight divisions it was useless to try to run the moulds, as they would not fill.

Cupola Control.

The test bar is also of great advantage for controlling the operation of the cupolas; running a test bar at any instant immediately discloses any defective feature of the apparatus, whether it be through hanging up of the charges, or through irregularity of charging or oxidising.

Fluidity Test Applied to Non-Ferrous Work.

In the case of foundry work entailing copper alloys, the test bar for running qualities possesses a field of investigation still more extended, because the test bar, aside from the measuring of the degree of running ability, gives an indication as to the chemical composition of the alloys poured. Owing to the facilities afforded by Mr. Thibault, production manager of a large bronze factory in the Paris district, the authors have been able to complete his records on this point.

The test bar used was slightly changed in the stopper rod in the basin and by slightly increasing the capacity of the basin, so that its contents are a little above the volume of metal necessary for filling the spiral and its gate. Thus designed, the test bar allowed of the determination of the composition of alloys cast, while investigating the running qualities of different typical alloys and by examining the influence of the alloying metals on the different mixtures.

Table I sets out the data of experiments made by Mr. Thibault, and shows the influence of the special elements on the running qualities. These results were obtained with alloys strictly graded, and by running four tests on each alloy. Another especially interesting point consists in the examination for copper of the best deoxidiser which would be capable at the same time of increasing the very poor running qualities of this metal, while at the same time improving its mechanical qualities.

Having to run very thin castings in copper, experiments were undertaken by employing successfully as deoxidising agents zinc, manganese, nickel, phosphorus, aluminium, magnesium and silicon.

All of these have increased the running qualities by three or four divisions, but it is found that the employment of silicon, magnesium and aluminium, and even of zinc, had the effect of causing the test bars to break on taking them out. This defect was confirmed when running pieces under the same conditions. It would accordingly seem that the best deoxidising agents to use would be manganese, phosphorus, and nickel, the latter, however, not giving good results except on condition of being incorporated under the form of 50 per cent. zinc-nickel.

It was also noticed that with a sound and deoxidised copper it was possible to straighten the spiral of the test bar and again to roll it in spiral form in a contrary direction. The test bar accordingly has not only given results on the running qualities and chemical composition of the cast metal, but also on its malleability. Without insisting any further, it can readily be seen how great a use the non-ferrous foundryman can derive from this test bar.

As to brass, owing to the influence exercised by the variation of the ratios between copper and zinc and its effect on the running qualities and malleability, the test bar will also supply to the foundryman several accurate observations.

For instance, it has been found that the running qualities of brass, 65 copper to 35 zinc, will hardly exceed eight divisions. With the same proportion of copper-zinc if the mark of eight was exceeded, there was always found incorporated in these brasses in small quantities such metals as aluminium, silicon, iron, etc., but at the same time, while the running qualities increased, it was found that the malleability decreased. This is the kind of brass that exhibits high strength. In these alloys the ratio of copper to zinc is always approximately 60 to 40, and, accordingly, it is especially in the examination of metals introduced, such as aluminium, silicon, lead and iron that the test bar will be of considerable help. In fact, some of these additions will, once in a while, reach 4 to 5 per cent., and the profound influence which they exercise on the calculated composition of the alloy is well known.

In this way a high-tensile brass, which possesses high strength with a small percentage of aluminium, has a running property that might reach 18 divisions, while the 60:40 ratio gives only 10. Above 14 divisions the test bar is brittle.

Finally, a last application of the test bar applied to the die-cast non-ferrous metals is in the examination of the influence exercised by the linings of the mould. As an example, it has been found that a brass (65/35) giving 8 divisions to the test bar can be made to give as high as 12 divisions if care is taken to spray a naphtha residue or linseed oil on the mould.

TABLE I.—*Results Obtained with the Test Bar on Running Qualities of Non-Ferrous Metals (Four Tests per Alloy).*

	Cu	Sn	Zn	Pb	Ni	Al	Fe	Mn	P	Si	Miscellaneous.	Fluidity qualities in division.
Copper	99.5	—	—	—	—	—	—	—	—	—	0.5	6*
	93.0	0.85	1.15	0.75	—	—	0.25	—	—	—	—	9†
	92.95	0.65	0.85	—	—	—	—	—	—	1.45	0.05	11‡
	93.0	—	1.50	—	1.42	—	—	—	—	—	0.08	11§
Bronze—B¹ ..	90.0	8.0	2.0	—	—	—	—	—	—	—	—	14
	90.0	7.5	1.0	1.5	0.05	—	0.25	—	—	—	0.20	18
Bronze—B² ..	86.0	14.0	—	—	—	—	—	—	—	—	—	16
	85.0	13.0	1.22	0.08	0.20	—	0.10	—	—	—	0.40	21
Bronze—B³ ..	86.0	12.0	1.88	—	0.04	—	—	—	0.03	—	—	18
Bronze—B⁴ ..	77.0	8.0	—	15.0	—	—	—	—	—	—	—	14
	76.5	7.5	—	14.5	1.0	—	0.5	—	—	—	—	16
Marine—88/12 ..	88.0	12.0	—	—	—	—	—	—	—	—	—	12
	86.16	10.96	1.35	1.42	Traces	—	0.03	—	—	—	0.08	17
Marine—90/10 ..	90.0	10.0	—	—	—	—	—	—	—	—	—	10
	89.94	9.63	—	0.17	0.06	—	0.01	—	—	—	0.19	12
Brass—70/30 ..	70.0	—	30.0	—	—	—	—	—	—	—	—	7
Brass—68/35 ..	65.0	—	35.0	—	—	—	—	—	—	—	—	8
Brass—60/40 ..	60.0	—	40.0	—	—	—	—	—	—	—	—	10
Brass—H.T. ..	58.2	38.8	—	—	0.5	—	1.0	1.5	—	—	—	12‖
	55.2	37.3	—	—	2.0	2.00	1.5	2.0	—	—	—	18‖
	55.2	36.8	—	—	4.2	—	0.2	2.8	—	—	0.8	14‖

* Metal badly oxidised.
† Metal sound, the spiral is carried back to the straight line, it breaks if the tests of malleability are continued; this is the indication of the presence of Sn and Zn.
‡ If the running qualities have been increased, this fact is indicated by breaking of the test bar in hot condition; the pieces are very malleable when in cold condition.
§ Has not any increased running qualities nor malleability in increasing the assumed percentage of copper doing away with the effect of Zn.
‖ These H.T. brasses run as cold as possible.

Making a Large Circular Cover.

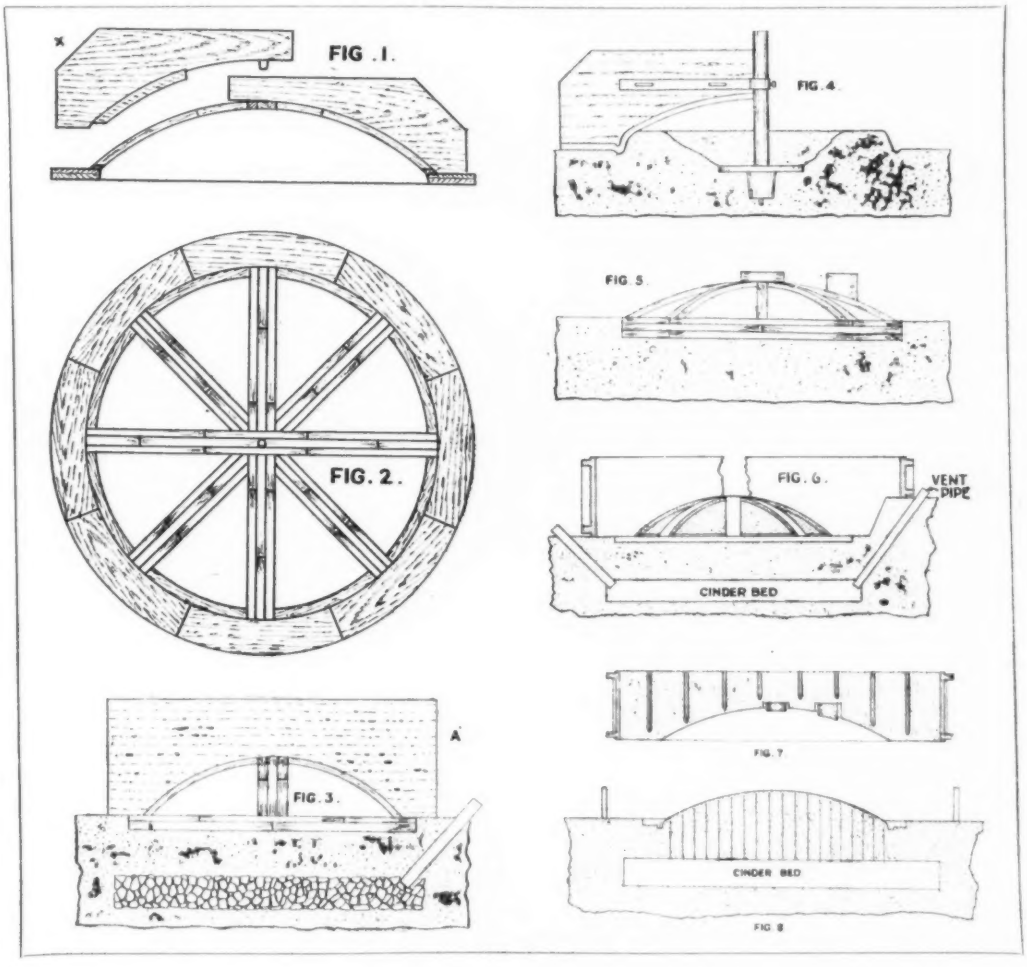
By Ben Shaw and James Edgar.

Small dish-shaped covers are fairly common jobs in many shops, and, if a number of castings are required, it is worth while to build up a solid pattern, but in the case of castings that are, say, six feet in diameter a solid pattern is extremely costly and there is no gain in making one: indeed, from the moulder's point of view, it is often preferable to have a skeleton pattern. For comparatively small castings it may be thought advisable to have a block pattern and corebox. A shell pattern cannot be bedded as easily into the foundry floor as a block pattern. It is necessary to adopt the method of turning over when dealing with such a pattern, especially if it has a domed shape, and, for this method, moulding boxes are essential. This is necessary because of the difficulty of ramming the sand to an equal density, unless the drag part of the mould is prepared in an upside down position and afterwards turned over preparatory to proceeding with the cope.

It is obvious in view of the above fact that, especially for large work, skeleton-shell patterns have considerable advantages over full-shell patterns, and there is no need to adopt the turn-over method. One very important advantage of this to the foundry is that it reduces the need for moulding boxes, and it reduces handling difficulties which is of importance in small foundries with limited crane facilities.

In the case of comparatively small jobs when a skeleton-shell pattern has been determined on, the shape may be determined by two pieces half lapped at the crown or centre. For very large jobs it may be advisable, in addition to two half-lapped pieces, to fit additional section pieces between them as at Fig. 2. With this type of pattern two strickles would be provided as shown at Fig. 1, one having a profiled edge following the external contour and the other the inner shape. Both of these strickles would be dowelled to suit a dowelled hole in the crown in order that they may be revolved about the centre to form both the inner and outer shape not determined fully by the pattern.

The flange for such a pattern would be built in two or three laminae of segments glued and screwed. Instead of turning it the segments might be made accurately to the template so that both inside and outside the flange could be finished off with a spokeshave; an alternative method is to finish off at the sandpapering machines. The section pieces are shown in Fig. 2 made in three laminae of segments, but two are often quite sufficient.



Practical Details.

When the mould is being made from such a pattern, the foundry floor being used as a drag, it is necessary to make a bearance upon which the pattern will rest flat. As the pattern is somewhat fragile and cannot be pressed into the sand to form its own bearance, a special procedure must be adopted. When there is no spigot an ordinary level bed is all that is required, and upon this the pattern is laid and maintained in position by means of weights resting on the top of the flange. Spigots are more frequently cast on the flanges of large conical or dome-shaped covers, although on smaller covers it is usually considered better to machine them from solid flanges. While this

reduces the time in the machine shop, more time is occupied in the foundry because a special bearance is necessary. For this bearance a strickle is used, which strickle need not follow the internal shape of the required casting as it is only required to form a seating for the flange.

Rigging up the Strickle.

A vertical spindle is necessary with a centre plate or footstep in which it can revolve. The centre plate is bedded into the foundry floor and tested for being level before the spindle is put into it. The strickle is bolted or clamped to a spider which passes over the spindle to which it is secured by a set screw. The man who is experienced in this class of work does not need to be reminded how important it is that the bearance should be definitely horizontal. It does not, of course, matter whether the strickle is made to fit against the spindle, as shown at Fig. 4, or a shorter board may be used with a gauge stick for setting it at the correct distance from the spindle. If the top edge of the strickle is made parallel with the bearance edge the horizontal position can be tested conveniently with a spirit level.

The preparation of the bearance when there is a spigot is not a very difficult matter and the pattern can then be weighted to hold it in position. Sand is rammed inside the pattern through the skeleton shell, and as the pattern shape becomes nearly filled the sand should be carefully tucked under the shaped pieces of the pattern. It is less difficult to use the fingers, and the density of the sand is more regular than when the peen rammer is used. When the sand has been rammed so that it projects beyond the skeleton pieces one of the strickles may be used to sweep off the surplus sand and make the required shape between the skeleton pieces. In this way the full outside shape of the required casting is formed and making the cope can be commenced.

Section Pieces in Large Casting.

In the case of very large castings more section pieces are necessary than for smaller jobs, not only because they define the shape more accurately than strickles, but in order to ensure greater rigidity; there is less possibility of the crown being lifted while the mould is being rammed. There is often a number of ribs, facings and bosses on patterns and these cause additional section pieces in order that they may be secured in their proper positions. When there are many section pieces there is not the same need for strickles, either to form the internal or external shapes unless the metal is very thin.

With regard to the cope, to the experienced man this is a fairly straight-forward job, a suitable box being located about the pattern and riser and gatesticks being introduced during the process of ramming up. If great care is not taken in ramming the cope the sand pattern may be distorted. The cope box can be lifted after careful staking to mark its position. As the sand forming the external shape of the pattern has now fulfilled its purpose it is necessary to remove part of it so that it will follow the internal contour of the work. The strickle X (Fig. 1) is very useful here as it gives a regular shape to the drag before the pattern is lifted. A certain amount of shaping must be done with the trowel as the strickle will not cover the whole of the spaces between the skeleton pieces; as a rule, however, the amount to be made up is small and is easily done without destroying the regularity of the shape as a whole. When the pattern is lifted, the runners made and other necessary work completed, the cope can be returned to its former position preparatory to casting.

Fig. 3 shows the pattern with the flange bedded in and the template A shown is for testing the pattern for sag as the mould is being rammed. Fig. 6 shows the drag completed and the box in position ready for the cope to be proceeded with. It will be observed that a cinder bed is shown. Figs. 7 and 8 show cope and drag completed. In all castings of a similar kind to that we have been discussing a cinder bed is necessary and it should be from 6 in. to 9 in. below the bearance. This is necessary for venting purposes. When the domed shape is formed the vent wire should be used liberally right down to the cinder bed. The vent holes can be sleeked over so that metal cannot enter them. Vent holes introduced when making the cinder bed are used to convey the gases, it is almost needless to say, outside the mould where they are fired. This practice is not, of course, peculiar to the moulding of skeleton patterns.

Chain, Nail, Bolt and Rivet Trades.

Third Census Report (1924).

The following particulars of the output in the year 1924 of firms in Great Britain whose returns were made on schedules relating to the manufacture of anchors, chains, nails, bolts, nuts, screws, rivets and kindred metal goods, have been issued by the Board of Trade. For the most part, the figures given are those of selling value, but in some cases weight is also returned. The total of chain and chain-cable products was 38,100 tons, with a selling value of £1,859,000 (including £87,000 in regard to chain the weight of which was not returned). The total weight of springs made (laminated and coiled) was 27,700 tons, valued at £1,188,000, a further £83,000 being credited to springs not separately distinguished. As regards nails (other than wire nails) and rivets, the value is given as £2,574,000, and that of bolts, nuts and screws as £5,364,000. These returns, along with the value of kindred metal products, jobbing and repair work, and work done for the trade, make a grand total of £13,083,000.

In the case of most of the special classes of products mentioned, supplementary amounts of varying importance were returned on schedules dealing primarily with other manufactures of metal. For example, the production of wire nails by firms making returns on schedules for the wire-drawing and manufacturing trades was shown as 11,500 tons, valued at £243,000. The total value of the output in 1907 of all these classes of products was recorded as £5,975,000, of which £659,000 represented that of goods returned on schedules for trades other than that now under review.

Owing to the restrictions imposed by the Census of Production Act, 1906, particulars of production in 1907 in terms of quantity could not be required, nor could any differentiation be required between goods of iron and steel and goods of other metals. Comparison between production in the two years is, accordingly, only possible by grouping together certain of the classes of goods for which separate information was obtained in 1924. Arranging the 1924 aggregates given above as far as possible on the lines of the classification in 1907, the figures of selling value for the latter year are as follow:—Chains and chain cables, £631,000; nails, tacks, rivets and washers of iron and other metals, £1,768,000; bolts, nuts and screws of iron and other metals, £2,819,000. The total average selling value per ton of chains and chain cables made in 1907 was about £18, of bolts and nuts about £16, and of nails (other than wire nails) and rivets about £10. In 1924 the average selling value per ton of these products was, for chains and chain cables, £49; for bolts and nuts, £29; and for nails (other than wire nails) and rivets, £21.

Persons Employed.—The average number of persons employed during 1924 at the factories and workshops to which the foregoing statement of output relates was 33,620 (including 13,193 females), of whom 30,438 were recorded as operatives and 3,182 as management, clerical and technical staff. In 1907 the number of persons employed was returned as 28,024 (including 10,189 females), of whom 26,474 were wage-earners and 1,550 were salaried persons.

The total capacity of engines at the factories to which the statement of production in 1924 relates was 23,682 h.p., of which slightly over 10 per cent. was in reserve or idle during the year. The capacity returned in 1907 amounted to 22,998 h.p. The capacity of electric motors at factories was not ascertained in 1907. In 1924 motors aggregated 26,577 h.p.

THE HOME SECRETARY has issued the draft Regulations proposed to be made under Section 79 of the Factory and Workshop Act, 1901, in lieu of the existing Regulations of April 4, 1914, for the construction and repair of ships. Following lengthy negotiations, it is understood that the revised draft will be accepted by all the associations concerned. Copies may be obtained from the Factory Department, Home Office, London, S.W.1, and any objection to the draft Regulations must be sent to the Secretary of State within 21 days from September 13, and must state the draft Regulations or portions of draft Regulations objected to, the specific grounds of objection, and the omissions, additions or modifications asked for.

The Works of R. B. Tennent, Limited, Whifflet Foundry.

This Foundry is situated in Coatbridge, and is served by the London, Midland and Scottish, and by the London and North-Eastern Railway Companies. The firm was established in 1857 and incorporated in 1900, and is now one of the largest manufacturers of steel and iron rolls and general castings in Great Britain. The plant is capable of dealing with castings up to 100 tons in iron and to 40 tons in steel. The works' buildings comprise general offices, laboratory, pattern shop, roll foundry, jobbing foundry, dressing shop, jobbing dressing shop, machine shop and stores.

Pattern Shop.—This shop has a floor space of about 5,000 sq. ft., and is well provided with modern machine tools for the rapid production of patterns; these include circular and band saws, planing machine, turning lathe, sand-papering machine, etc.

Roll Foundry.—This foundry is 430 ft. long by 63 ft. wide, and is served by two 60-ton upper and two 25-ton lower overhead cranes. At one side of the foundry there are four coal-fired reverberatory air furnaces, one of 35, two of 25, and one of 20 tons capacity, all having removable roof sections for convenience in charging. In addition, there are two cupola furnaces for light castings. There are also 17 drying stoves provided. On the floor of the foundry are several deep pits, some as deep as 30 ft., in which the largest size of rolls are cast. A wheel-moulding machine and two moulding machines for light castings are also to be found here.

At one end of the foundry there is a Siemens open-hearth melting furnace of 50 tons nominal capacity served by two Wilson-type gas producers. A special feature of the furnace is that a portion of the roof can be lifted off to permit of large pieces of scrap, such as "heads" or broken rolls, being charged. The furnace is at right-angles to, and at the end of, the roll foundry, and taps directly into it.

FIG. 1.—COATBRIDGE WORKS OF R. B. TENNENT, LIMITED. MAIN FOUNDRY.

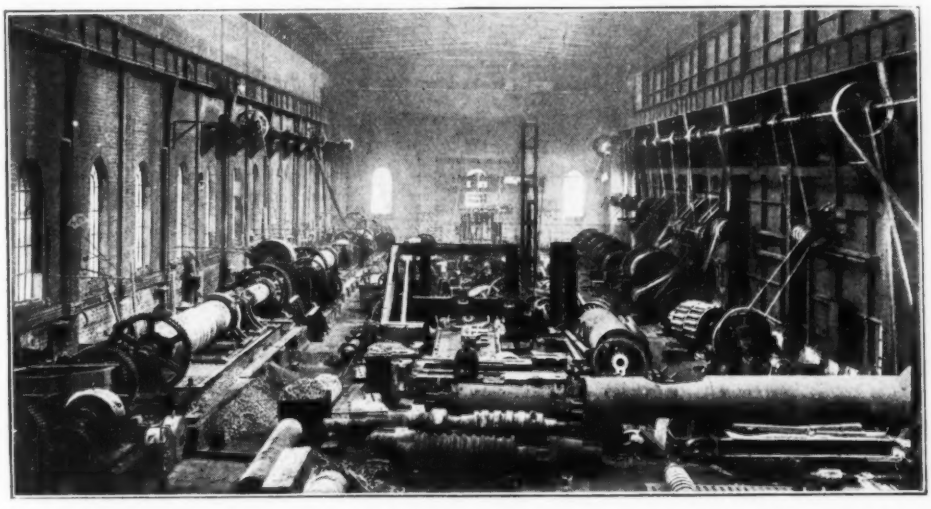


FIG. 2.—COATBRIDGE WORKS OF R. B. TENNENT, LIMITED. ROLL-TURNING AND ENGINEERING SHOP.

In the manufacture of steel rolls and other steel castings proper heat treatment is of vital importance. The firm have accordingly provided five large annealing furnaces with removable roofs to permit of rolls or other castings being placed in them. The heat treatment is controlled by electrical and optical pyrometers, so that the exact temperature can be maintained for the time required to produce the result aimed at.

Dressing Shops.—There are two dressing shops, with a total floor space of 14,000 sq. ft. One is

served by four electrically-operated post cranes, the other by one 40- and one 20-ton overhead crane. These shops are well supplied with pneumatic chipping hammers, saws for removing runners, etc.; also a complete sand-blast equipment.

Machine Shop.—The roll-turning and machine shop is housed in a building 253 ft. long by 62 ft. wide, served by one 60- and one 40-ton overhead crane. The equipment includes 13 roll lathes, ranging in capacity to that necessary to deal with the largest size of rolls now in use, one roll-grinding machine, wheel-turning lathes, vertical and horizontal planing machines, slotting and drilling machines capable of machining the heaviest mill housings and other rolling-mill castings.

In this shop there was finished the largest roll ever made in this country. It was 186 in. long by 50 in. in diameter on the barrel. The finished weight was 47 tons 6 cwts.

As examples of the works' various productions may be mentioned a cast-steel housing for a 42-in. plate mill, machined complete and weighing 32¼ tons; a cast-iron housing for a 44-in. cogging mill, machined complete and weighing 48¼ tons; machine-moulded cast-steel mill pinions, having a total finished weight of 44 tons; a cast-iron anvil block, weighing 56 tons; also a large number of locomotive wheel centres for the London, Midland and Scottish Railway Company.

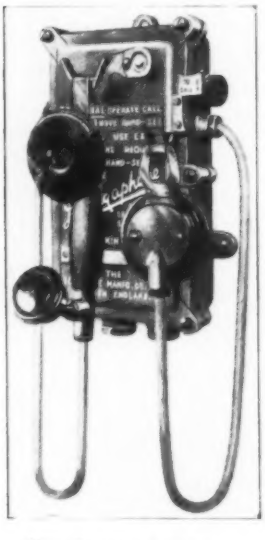
The whole plant is electrically operated. The current is obtained from The Clyde Valley Electrical Power Company, and after being stepped down in static transformers, is changed to direct current in two rotary converters.

There is a complete chemical laboratory, where all raw materials are carefully analysed before use. There is also a very fine micro-photographic outfit for micrographical research work, and a testing machine capable of tensile and bend tests.

The Laryngaphone.

A "Din-Proof" Telephone.

Due to the fact that the ordinary type of telephone transmitter collects and records not only the voice of the speaker but also in some degree all other sounds reaching it, difficulty usually arises when communication has to be made from or to noisy situations such as power stations, haulage-engine rooms, etc. Often under such conditions it is found necessary to provide special compartments in order that conversation may be carried on without interruption. This involves expense, and any device that makes such provision unnecessary has open to it a wide field of usefulness.



THE LARYNGAPHONE.

At the recent Shipping, Engineering and Machinery Exhibition, at Olympia, the Telephone Manufacturing Company, Limited, Hollingsworth Works, West Dulwich, S.E. 21, were exhibiting their "Laryngaphone." A mining-type unit is shown in the accompanying illustration. The telephone instrument itself does not differ essentially from the ordinary type, the "Larnygaphone" feature being confined to the transmitter, which, instead of being spoken into, is pressed against the side of the mouth or throat, thus being prevented from recording any but the vibrations of the vocal cords through the walls of the throat, or from the bones of the jaw, and being almost entirely unaffected by external noises. Even with a motor siren in operation close at hand in a confined enclosure our representative was able to carry on a conversation without difficulty.

Blast Furnace *v.* Direct Process of Steel-Making.

In the course of an address on "The Production of Iron and Steel Direct from the Ores," given to the Middlesbrough Rotary Club, on Friday week, MR. HAROLD WRIGHT (chief chemist of Messrs. Dorman, Long and Company, Limited.) observed that the modern tendency in the commercial use of steel was always towards larger sizes, and some of the masses of steel used required ingots 5, 7, 10 and 15 tons in weight. Whatever might be the theoretical disadvantages of the blast furnace, which he disputed were nearly as great as were alleged, the presentation of iron in liquid form facilitated the mechanical handling of the raw product.

The question of getting the material to the steel furnace was therefore chiefly a mechanical one. If iron was delivered in a molten form it was one which could be most easily handled, and that was why the blast furnace seemed still to have a future before it. He pointed out that from 10 to 12 per cent. of the total potential heat of the fuel used existed for use at the steelworks, and about 25 per cent. was actually absorbed in the reduction of the iron from its oxide. Also, according to the fuel used in the furnace, 50 to 70 per cent. of the potential heat of the fuel existed in the furnace gases. To that extent the alleged fuel inefficiency of the blast furnace was to be combated because the heat passing away in the slag could also possibly be made use of.

Direct processes as they were called, where iron was directly made from ores and made malleable, were always being discovered. Under some local conditions it was possible for such processes to achieve enough success to carry on, but the direct process to prepare the large masses of iron called for to-day presented some very great difficulties. To facilitate reduction most of the direct processes ground the iron ore very fine before treatment. The drawback of getting material fine to ensure reduction was that upon heating to agglomerate the particles it also facilitated reoxidisation. They had to be most careful in heating even solid steel or air penetrated it and made it unweldable. The difficulties in agglomeration, which was the chief virtue of the blast-furnace method, offered the chief difficulty to the direct methods. Electric melting had been suggested as a means of getting over this difficulty, but it was far too expensive for making steel at commercial prices.

The greatest difficulty of all arose in melting by flame without oxidisation, as there was difficulty in getting the heat into a mass of fine material, and the steel smelter knew there was no possibility of making satisfactory steel should the furnace slag contain too much iron oxide. The ordinary blast furnace represented what evolution and the survival of the fittest had brought about in competition with the direct processes. Mr. Wright expressed the view that there were very few real drawbacks to the full use of the blast furnace when the object was the production of large masses of malleable iron or steel for commercial use.

Patent Specifications.

9,673. THOMAS & COMPANY, LIMITED, R., and JONES, E. A. Valves for controlling the flue passages of furnaces. April 13, 1926. 275,697.

2,936 BENNIS, A. W. Chain-grate furnaces. Feb. 2, 1926. (Cognate Application, 30507/26.) 275,290.

3,059. BENNIS, A. W. Chain-grate furnaces. Feb. 3, 1926. (Cognate Application, 30586/26.) 275,428.

12,129. GUSTAFSSON, E. G. T. Processes for producing metals in electric furnaces. (May 16, 1925.) 252,162.

19,004. HATFIELD, W. H., and GREEN, H. Treatment of the surfaces of stainless or rustless steels or irons. July 30, 1926. 275,781.

19,716. CRIST, D. M. Process of metallising ores and recovery of metals and by-products. Aug. 10, 1926. 275,791.

30,544. SIEMENS-SCHUCKERTWERKE GES. Bright annealing furnaces. (Dec. 3, 1925.) 262,445.

167. SOC. BELGE DE L'AZOTE (SOC. ANON.). Lead columns or pipes. (Jan. 4, 1926.) 263,881.

Is "Burning-on" a Success?

BY "PRACTICIEN."

The practice of "burning-on" has always been a subject of much criticism, and in some foundries is absolutely forbidden. Nevertheless, the foundryman is apt to think twice before he condemns a casting to the scrap heap, particularly in the case of castings which have entailed a great amount of time and labour to produce. The question arises, "can the flaw or break be made reasonably good by burning-on?" Maybe the nature of the defect renders burning-on impossible, the only possible alternative may then be welding and the application of Tobin-bronze. There are, however, many defective castings which might be saved by resorting to "burning-on," *e.g.*, (1) the joining together of two or more broken parts, (2) the building-up of a short-run casting, (3) parts of the casting wrongly omitted from the pattern, (4) brackets, flanges, etc., broken off accidentally in the fettling shop or in transit, (5) filling up a blowhole or cavity in the metal, (6) superficial faults in the casting. It should be noted, however, that the above examples, although typical of the defects yielding to the operation of burning-on, would sometimes be better if welded or fused. Careful examination coupled with a certain amount of practical experience and discretion can alone determine the better method of procedure. Large or bulky castings do not yield successfully to this treatment This is, of course, due to the fact that the heat which should be concentrated at one point is quickly absorbed by the surrounding volume of metal, thus defeating the main principle underlying the process of burning-on. There are, however, exceptions to every rule, the following example may serve as an illustration in this particular case. The casting in question was a shed roof-gutter, 12 in. by 8 in. section, about 23 ft. long, and weighed about 18 cwt. Each end of the gutter had heavy jointing flanges, one of which had been broken off in the fettling shop. Burning-on was tried and the result was so satisfactory that it was afterwards impossible to tell which of the flanges had been broken.

Important Factors to Note.

In general, "burning-on" consists of pouring molten metal in a continuous stream over the defective part until the two unite and fuse together. Many ironfounders regard "a burn" purely as a makeshift job, and should the result be satisfactory consider it a fluke or good fortune. This is due to not understanding and studying the subject. Not long ago the author came across an amusing example of this. The casting about to be burnt was prepared in the fettling shop—a distance of about 150 yards from the cupola tap hole. The ladle was filled and carried through the open to the broken casting, where the pouring was further held up for at least a minute. The result was failure, and "burning-on" was considered useless. It is obvious that, in this particular case, the method of procedure and not the principle of "burning-on" was at fault.

In order to obtain good results from "burning-on," strict attention should be paid to the following:—(a) The casting about to be "burnt" should be placed close to the cupola tap-hole, and at the same time well away from any cold draughts. The latter, although most important, is more often than not totally ignored. (b) The surface of the break or defect must be quite clean. A smooth file will generally remove any superfluous matter. (c) Attention should be paid to the class of casting being made on the particular day that the "burn" is to be made, since it is advisable to use a similar mixture of metal for the burn as that used for the casting. A much better fusion takes place if this is carefully observed. (d) Always have a good head of hot, fluid metal. Sluggish metal is entirely useless, fusion being practically out of the question. (e) Use a ladle of such a capacity that it will not be necessary to return to the tap-hole for more metal. (f) Whenever possible, the casting to be burnt should, beforehand, be made red-hot in the region of the defect, thus equalising the ultimate contraction, and shortening the time taken for effecting the burn. Waste of molten metal is thus prevented. Coke fires are generally employed for this purpose, the heat being gradually applied to the casting. (g) To ensure complete fusion test with a small wrought-iron rod. (h) After the burn is accomplished, leave the casting to cool slowly. Never attempt to knock off the riser when the metal is setting, for this is liable to cause fracture at the old break.

Points to Consider before "Burning-On."

There are numerous points to consider before finally deciding to "burn" a defective casting. The following is a brief outline of the more important. (1) The cost of a new casting as compared with that of repairing the defective one—should the difference be only slight it is always better to make a new one, unless the casting is exceptionally urgent. (2) The nature of the defect—sometimes welding is better than "burning-on." (3) The design of the casting. Should the casting be under great strains, due to abrupt changes in section, it is inadvisable to adopt this process. In the case of thin castings, great difficulty should not be met with if sufficient care is taken. Thin castings may be cracked through allowing too much metal to flow over the parts adjacent to the break, unless precautions be taken by the pourer. (4) The ultimate requirements of the casting—castings subject to great tension or compression when in use, should never be burnt. Cast-iron columns and cracked pulley arms, for example, should never be "burnt-on." (5) Should the burnt part require machining, great care should be exercised in the mixture of the new metal. The part which has been "burnt-on" will be found to be considerably tougher than the remaining part of the casting. (6) Never allow the customer or the maker's reputation to suffer through the risk connected with "burning-on." If, in any particular case, "burning-on" is considered risky it is better to make a new casting.

Burning a Short Run Pipe-Flange.

Pipes are, as a rule, one of the most common types of castings which come in for "burning-on." Take, for example, the flange of a pipe being short-run. A mould is prepared from a piece of dry-sand core. This is scooped into the shape corresponding with the missing part of the flange, but slightly larger. The core is placed on the pipe-flange where short-run and moved round it, with a sliding action (exerting a little pressure, of course), until the flange has worked a clear groove similar to the missing part of the flange, but slightly deeper. Next remove the core and make a gate to the improvised mould. An outlet opposite to the gate is also necessary. This allows the surplus metal to flow away and to act as an indicator of when fusion has taken place. The pipe should beforehand be heated to a high temperature, and then embedded in the sand, the short-run part of the flange being at the top of the mould. Place the mould on top of the flange and hold it down by means of suitable weights. Everything is now ready for the pouring, which should, as previously explained, be done with good, hot, fluid metal. Pour slowly, skim well, and at the same time watch the outlet. Immediately the flow of metal ceases at the outlet, stop pouring, for this is an indication that complete fusion has (or should have) taken place. Leave for a time to cool, and then remove the mould. Care should be taken in knocking off the gate. In many foundries this is done in the fettling shop, no risk being taken.

General Remarks.

Little difficulty should be experienced with "burning-on" if the points outlined are strictly observed. Above all "burning-on" should never be regarded as a makeshift. There is no reason why it should not be successful, for it is certainly a theoretical and practical possibility. The author believes that many castings which have and are being rejected as wasters could be saved and made reasonably sound if treated in this way.

Always test a casting which has been burnt before it leaves the works. When painted over, the burnt part cannot be detected.

XUM

Trade Talk.

The Admiralty has just placed orders for two minesweepers to be built and engined by R. & W. Hawthorn, Leslie & Company, Limited, of Newcastle-on-Tyne.

Automatic and Electric Furnaces, Limited, owing to the continued expansion of their business, are moving their offices and works to larger premises at Elecfurn Works, North Road, Holloway, N.7, on September 29.

Swan, Hunter & Wigham-Richardson, Limited, Wallsend, have secured a contract from the Commonwealth and Dominion Line for two large motor ships of about 11,500 tons deadweight for the Australian meat and fruit trade.

The opening meeting of the session of the Institution of Locomotive Engineers (London), is arranged to be held at Denison House, Vauxhall Bridge Road, S.W.1, to-day, Thursday, September 29, at which Mr. H. N. Gresley will deliver his presidential address.

The North British Locomotive Company, Limited, Glasgow, have received a contract for 18 superheated locomotives for the Rhodesia Railways, and Beyer, Peacock & Company, Limited, Gorton Foundry, Manchester, a repeat order for six locomotives for the Leopoldina Railway.

The steamer "Gwentgate," with a cargo of 2,417 tons of Continental iron and steel for Mordey, Son & Company, commenced discharging at Newport Docks on September 12, at 8 a.m., and finished at 2.45 p.m. on the following day. The net working time was 59 crane hours, and the average rate of discharge approximately 41 tons per crane per hour. The vessel then proceeded to a loading berth and commenced to load an outward cargo of coal at 8.45 p.m. on the same day, and completed at 12.10 p.m. on September 14, after having a total of 2,364 tons of cargo and bunkers. After completion of loading, the steamer moved straight to the locks, and sailed at 1.10 p.m. the same afternoon.

The forty-seventh session of the Junior Institution of Engineers opens on Friday, October 7, when a lecture by Prof. Edwin Edser on "Lubrication" will be delivered in the Lecture Room of the Institution at 39, Victoria Street, S.W.1. Amongst the more important papers to be submitted during the session may be noted "Piling Work; Its Latest Developments," "Engineering Salesmanship," "Management Graphics," "Air Conditioning," "Steam Accumulators," "Pulverised Fuel," "Automatic Electrical Substations," "Air Compressors," "Electro-Chemical Deposition of Metals," etc. The inaugural meeting will be held on November 18 at the Caxton Hall, when Sir Murdoch Macdonald, M.P., will deliver his presidential address.

As recently announced, the Hodbarrow Mining Company, Millom, Cumberland, have placed a contract for the sinking of a new shaft by means of the freezing process. A contract has now been placed for an electric winding plant with the Metropolitan-Vickers Electrical Company, Limited. The mechanical parts of the winder are being made by Murray & Paterson, Limited, Coatbridge, and the method of winding is by means of skips with automatic tipping and delivering to an aerial ropeway. Extensive additions to the electrical system are in hand for transmitting power from the company's generating station to the new sinking, and the contract for this has been placed with Mr. R. M. Russell, Glasgow. To meet the increased demands for compressed air, an order has been placed with Belliss & Morcom, Limited, Birmingham, for an additional compressor, this being steam driven and duplicate of one installed a few years ago. The consulting engineers for the scheme are Walter Dixon & Company, of Glasgow.

To commemorate the memory of the founders of Netherton and Old Hill Ironworks, and particularly the late Sir George Hingley, Bart., and Mr. H. M. Hingley, a spacious pavilion has been erected on the sports ground of the Hingley Athletic Club at Old Hill. At the opening ceremony Mr. C. E. Lloyd, M.P., chairman of the directors, who presided, referred to the history of the business, extending over 100 years, and said it had justly grown because of the care and energy of those associated with it. The object of the firm had been to try to improve the relationships between the employers and workmen, and they took a leading part in the formation of the Midland Wages Board, an organisation which had been a model for all similar developments. It had an unequalled record in effecting friendly settlements in industrial conditions between masters and men, and their firm were proud to have been associated with the movement. Miss L. Hingley performed the opening ceremony, and also unveiled a memorial tablet to her brothers.

Personal.

Mr. D. J. Parsons, who was pig-iron salesman for over six years with Messrs. J. C. Abbott & Company, Birmingham, has been appointed assistant to Mr. F. Fillmore, the Birmingham and South Wales Agent for The Stanton Ironworks Company, Limited, near Nottingham. Mr. Parsons will be taking up his new duties on November 1.

Mr. Dane Sinclair has been elected chairman of the British Insulated Cables, Limited, in place of the late Mr. James Taylor, J.P., and to combine therewith the office of managing director. Mr. Sinclair, who has been associated with the company over a long period of years, was born in Caithness in 1852, and spent the early part of his career in the telegraph department of the North British Railway. He subsequently entered the service of the Japanese Government, and in 1875 he was appointed Inspector of Telegraphs in Japan. On relinquishing that post five years later he joined the National Telephone Company as engineer for the Glasgow district. After the amalgamation of the three principal telephone companies of Great Britain he became London manager, and in 1892, engineer-in-chief. He joined the British Insulated and Helsby Cables as general manager in 1902.

Wills.

Jack, Alexander George Mackenzie, of Rockhills, Psalter Lane, Sheffield, lately Deputy Chairman of Hadfields, Limited, who died on August 2,	£108,540
Pearson, Joseph Frederic (70), of The Birches, Hagley, Worcester, ironmaster, who died on March 28	£102,894
Shaw, Charles Albert (54), of Glenbourne, Dore, near Sheffield, managing director of Messrs. John Shaw, Limited, Yorkshire Wire Rope Works, Sheffield	£10,674
Bailey, Edward Vernon (74), of Avenue Road, Leamington, and of Great Hampton Row, Birmingham, retired brass founder	£8,373
Templer, C. L., of 58, Clifton Road, Rugby, a director of the Yorkshire Engineering Supplies	£5,500

Contracts Open.

Belfast, October 1.—Steam, water and other piping, etc., for the Electricity Committee, viz.:—Section (1) Cast-iron water pipes; (2) steel steam, exhaust and drain pipes; (3) water valves and fittings; (4) steam, feed and drain valves and fittings; (5) steam receiver; (6) pipe coverings. Mr. F. H. Whysall, city electrical engineer and general manager, East Bridge Street, Belfast. (Fee £2 2s., returnable.)

Edinburgh, October 8.—Iron, steel, nickels, etc., for the Corporation. The Lighting and Cleansing Department, 331, High Street; the Central Fire Station, Lauriston Place; the City Road Surveyor, City Chambers.

Newton Abbot.—Ten tons of 6-in. and about ten tons of 9-in. new or secondhand cast-iron pipes, for the Urban District Council. Mr. S. Olver, highway surveyor, 9, Marlborough Terrace, Bovey Tracey.

Weymouth, October 10.—Stores, for the Town Council: Castings, etc. The Borough Surveyor, Municipal Offices.

Company Meeting.

Clayton & Shuttleworth, Limited.—Presiding at the 26th annual meeting, in London, the chairman (Mr. C. T. Blacklock) reviewed the year's working. Comparing 1925 with last year, he said the actual manufacturing and trading loss amounted to £6,991, which, with the addition of the bank interest and fees, less a small transfer fee income, gave a total of £10,994, a precise comparison with 1925, when the loss was £13,071. "From this standpoint," he said, "there was during 1926, in spite of the immense difficulties arising out of the long strike, a slight improvement." Dealing with the sum of £3,593 (which has been written off) expended during the year, in exhaustive trials at the new works, and in the field abroad, of a new production, the chairman stated they had sufficient reasons for believing that the machine in question would before long bring important benefits to them, and more work at their Lincoln factories. New productions, he pointed out, are not marketed profitably with great speed, but they could take it that they would presently complete their plans for selling this new machine aggressively and in growing intensity.

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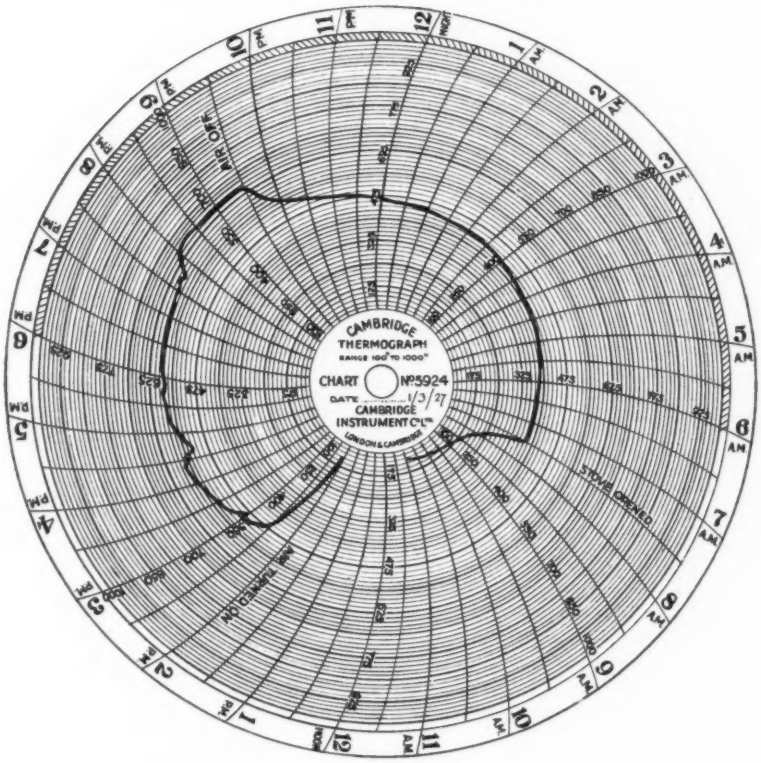
are saving over £1,000 a year for one engineering works alone. Let them save for you too.



Here is PROOF POSITIVE. Just look at this chart, reproduced by permission of Messrs. Bertram & Co. of Sciennes, Edinburgh. Note the rapid rise in temperature, the consistent run and slow, even fall, giving a maximum drying period. The stove in this case has a capacity of 1,900 cubic feet, and the total fuel consumption during the above period was *only* 4½ *cwts.* !

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IRON AND STEEL MARKETS.

Pig-iron.

MIDDLESBROUGH.—The marked improvement moted of late in the prospects of the Cleveland iron trade has been, so far, satisfactorily maintained, the heavy stocks accumulated a few weeks ago having been almost entirely liquidated, while the 2s. 6d. discount in favour of shipment and Scottish business has certainly stimulated increasing business in these directions. It is not improbable that the shipments of pig-iron this month will be the best for any month this year, and further sales to European purchasers are reported recently. It is further satisfactory to learn that each successive week of late has seen sales exceed output, and to-day the reserves on makers' hands are no more than sufficient to maintain a healthy margin in case of emergency. Subject to the above-mentioned discount, the prices of the different classes of Cleveland iron are as follow:—No. 1 foundry iron, 70s.; No. 3 Cleveland G.M.B., 67s. 6d.; No. 4 foundry iron, 66s. 6d.; No. 4 forge, 66s. per ton.

Although not, as yet, fully recovered from recent depression, the Tees-side hematite market is making steady progress in that direction, makers now reporting that sales are slightly in excess of demand. Prices, however, remain unaltered, East Coast mixed numbers being quoted at 75s. per ton, with 75s. 6d. as usual for No. 1 quality. No change is observable in the North-West Coast, Bessemer mixed numbers figuring nominally at 75s. per ton at works.

LANCASHIRE.—Buying on foundry account in the local iron markets continues on a steady scale, though still mainly confined to consumers' more immediate needs. Derbyshire brands of foundry iron are maintained at 73s. to 73s. 6d. per ton, delivered locally, with Staffordshire makers nominally firm at 74s. 9d., although offers of the latter at a substantially lower figure have been reported.

THE MIDLANDS.—Local demand for foundry pig continues disappointing, forward buying especially being limited in extent, and mostly dependent upon the volume of orders in consumers' books. Northamptonshire No. 3 iron is offered at 60s. 6d. per ton, Derbyshire 65s., and North Staffordshire also at 65s., f.o.t. furnaces. Other pig-irons are without change.

SCOTLAND.—The tone of the Scotch pig-iron market is not quite so depressed, makers reporting that there has been a little better demand and a moderate amount of business has been put through. Prices, however, are again easier at 73s. 6d. for No. 3 Scotch foundry, f.o.t. furnaces.

Finished Iron.

Business in the various departments manufacturing finished material continues extremely slow, with many mills and works having insufficiently filled order books to ensure regular running, while having also to contend with fierce outside competition. This is notably apparent in connection with crown iron and cheaper qualities of bars, Staffordshire makers, for instance, finding very keen competition from Lancashire and Derbyshire for the limited business available; £9 10s. is quoted for crown iron for orders of any size, and £9 15s. to £10 is quoted for small lots. Nut and bolt iron is offered round about £9 delivered South Staffordshire, but the call for it is very meagre indeed. Even for the foreign iron, business is reported to be rather stringent. Staffordshire marked bars are unaltered at £13 10s. at makers' works.

Steel.

In the Sheffield steel market buying is on the light side. Acid billets are quiet, and there is not much doing in basic billets, with the exception of soft qualities, for which there has been a heavier call lately. Hard basic billet prices have been reduced by ten shillings a ton, and now range from £7 12s. 6d. to £8 2s. 6d. per ton delivered. Soft basic, on the other hand, have moved up by five shillings to £7 5s. per ton delivered. In the tinplate market the home trade is quiet all round. Current rates are about 18s. 3d. to 18s. 6d. basis for coke primes, and 17s. 3d. to 17s. 6d. basis for wasters, net cash, f.o.t. at makers' works.

Scrap.

Symptoms of reviving interest in the markets for scrap metals are now evidenced in one or two instances, and on Tees-side there have been inquiries for heavy machinery cast iron in handy pieces at 65s. per ton, but there is only a limited demand for ordinary quality at 61s. and cast-iron borings at 42s. 6d. per ton. In Scotland there is no alteration in the price of machinery cast-iron scrap, which is exceedingly easy around 68s. 6d. to 70s. per ton. Heavy ordinary cast-iron scrap is also easy, and odd lots are being picked up around 63s. 6d. to 64s. 6d. per ton. Old cast-iron railway chairs are still around 69s. to 70s. per ton, with few buyers. Light cast-iron scrap is also unchanged at 57s. 6d. to 58s. 6d. per ton, with little business doing. The above prices are all per ton delivered f.o.t. consumers' works.

Metals.

Copper.—During the past week movements in the market for standard copper have been dull and uneventful as compared with other sections of base metals, but, in the absence of selling pressure, fluctuations were narrow and the volume of business in the open market was only limited. Unless an improvement takes place in the American position, in regard to which advices are rather more encouraging, there is perhaps not much to be expected as to a renewed advance, although it remains to be seen how the statistics will pan out.

Official closing prices of standard copper have been as follow :—

Cash : Thursday, £54 8s. 9d. to £54 10s.; Friday, £54 2s. 6d. to £54 3s. 9d.; Monday, £54 5s. to £54 7s. 6d.; Tuesday, £53 17s. 6d. to £54; Wednesday, £54 to £54 1s. 3d.

Three Months : Thursday, £54 17s. 6d. to £54 18s. 9d.; Friday, £54 11s. 3d. to £54 12s. 6d.; Monday, £54 12s. 6d. to £54 13s. 9d.; Tuesday, £54 3s. 9d. to £54 6s. 3d.; Wednesday, £54 6s. 3d. to £54 8s. 9d.

Tin.—The downward tendency in values of standard tin noted towards the close of the week's markets is attributed to adverse American advices, heavy bear selling, and realisations by speculative elements on this side, with the result that prices have been forced down to the lowest level recorded this year. It appears almost certain, however, that supplies are now increasing, while world consumption is below normal, and, until these conditions are more equally balanced, it would seem hopeless to expect an improvement in either demand or values.

Official closing prices of standard tin have been as under :—

Cash : Thursday, £273 10s. to £273 12s. 6d.; Friday, £270 17s. 6d. to £271; Monday, £268 to £268 2s. 6d.; Tuesday, £266 to £266 5s.; Wednesday, £263 to £263 10s.

Three Months : Thursday, £271 to £271 5s.; Friday, £269 to £269 2s. 6d.; Monday, £265 15s. to £266; Tuesday, £264 to £264 5s.; Wednesday, £261 5s. to £261 10s.

Spelter.—Conditions in the market for ordinary spelter are best described in the following brief report by a merchant firm :—"A little inquiry has been circulated, but sellers seem ready to meet what demand there is, and, unless the galvanising trade takes a decided turn for the better, it may be that more spelter supplies will be forthcoming than can be readily absorbed."

The following are the week's prices :—

Ordinary : Thursday, £27 6s. 3d.; Friday £27 2s. 6d.; Monday, £27 2s. 6d.; Tuesday, £27 5s.; Wednesday, £27 8s. 9d.

Lead.—The weakness in soft foreign pig previously reported continues unchecked, influenced by some rather free selling by dealers and a further reduction in the American price. Trade buying has been poor, despite the fact that consumers have very little stock.

The week's prices are appended :—

Soft foreign (prompt) : Thursday, £21 6s. 3d.; Friday, £21 1s. 3d.; Monday, £21 2s. 6d.; Tuesday, £20 17s. 6d.; Wednesday, £20 15s.

Latest Blackheart Malleable Strength Figures Outlined.

Professor E. Tonceda, writing in a recent issue of the "Iron Age," states that American Blackheart malleable castings now possess the following average properties. Tensile strength usually exceeds 23 tons per sq. in., whilst the yield point is at 16 tons per sq. in. The elongation is about 18 per cent. on 2 in. These tests are associated with a Brinell hardness of 115.

"LONG SOUGHT FOR—NOW FOUND" THE MATERIAL

Found Right, and is the
Only true Binding Material in
Use ALL OVER THE WORLD
No Up-to- : : : :
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Agents for—
DORMAN LONG
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"B.S. HEMATITE PIG-
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PIG IRON
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For Motor Castings.

FOUNDRY & FURNACE
COKE

J. C. ABBOTT & Co LTD
LLOYD'S BANK CHAMBERS, NEW STREET, BIRMINGHAM.
TELEPHONE: MIDLAND 170.

WEEKLY PRICE CURRENT.

COPPER.

	£	s.	d.
Standard cash	54	0	0
Three months	54	6	3
Electrolytic	61	10	0
Tough	59	0	0
Best selected	60	0	0
Sheets	86	0	0
India	71	0	0
Wire bars	61	10	0
Do. October	61	10	0
Do. November	61	10	0
Ingot bars	61	10	0
H.C. wire rods	66	10	0
Off. av. cash, Aug. 55	8	0	7/11
Do. 3 mths. Aug. 55	15	2	1/11
Do., Sttlmnt. Aug. 55	8	0	9/11
Do., Electro, Aug. 62	8	6	11/22
Do., B.S., Aug.	60	18	7½
Aver. spot price copper, Aug.	55	8	0½
Do., wire bars, Aug.	62	12	4½
Solid drawn tubes			12½d.
Brazed tubes			12½d.
Wire			9½d.

BRASS.

Solid drawn tubes	11½d.
Brazed tubes	13½d.
Rods, drawn	10½d.
Rods, extd. or rlld.	7½d.
Sheets to 10 w.g.	9½d.
Wire	9½d.
Rolled metal	9½d.
Yellow metal rods	7½d.
Do. 4 × 4 Squares	8d.
Do. 4 × 3 Sheets	8½d.

TIN.

	£	s.	d.
Standard cash	263	0	0
Three months	261	5	0
English	262	10	0
Bars	264	0	0
Straits	271	10	0
Australian	271	0	0
Eastern	269	15	0
Banca	277	0	0
Off.avr.cash, Aug. 293	6	0	2/22
Do., 3 mths., Aug. 296	13	7	7/11
Do., Sttlmt. Aug. 293	4	9	3/11
Aver. spot, Aug. 293	6	1	

SPELTER.

	£	s.	d.
Ordinary	27	8	9
Remelted	25	10	0
Hard	21	5	0
Electro 99.9	30	17	6
English	27	17	6
India	23	10	0
Zinc dust	36	0	0
Zinc ashes	9	0	0
Off. aver., Aug.	28	2	9/22
Aver., spot, Aug.	28	4	2½

LEAD.

	£	s.	d.
Soft foreign ppt.	20	15	0
English	22	0	0
Off. average, Aug.	23	6	7/11
Average spot, Aug.	23	2	4½

ZINC SHEETS, &c.

	£	s.	d.
Zinc sheets, English	36	0	0
Do. V.M. ex whf.	34	10	0
Rods	42	0	0
Boiler plates	34	0	0
Battery plates	33	10	0

ANTIMONY.

	£	s.	d.
Special brands, Eng.	64	15	0
Chinese	48	0	0
Crude	38	0	0

QUICKSILVER.

	£	s.	d.
Quicksilver	21	15	0

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro-silicon—	
25%	£8 17 6
45/50%	£12 15 0
75%	£20 5 0
Ferro-vanadium—	
35/40%	14/3 lb. va.
Ferro-molybdenum—	
70/75% c. free	5/- lb.
Ferro-titanium—	
23/25% carbonless	11½d.
Ferro-phosphorus, 20/25%,	£17 15 0
Ferro-tungsten—	
80/85%, c. fr.	1/3 lb.
Tungsten metal powder—	
98/99%	1/8½ lb.
Ferro-chrome	
2/4% car.	£33 0 0
4/6% car.	£23 0 0
6/8% car.	£22 17 6
8/10% car.	£22 10 0
Ferro-chrome—	
Max. 2% car.	£36 0 0
Max. 1% car.	£41 10 0
Max.0.70% car.	£53 0 0
70%, carbonless	1/4½ lb.
Nickel—99%, cubes or pellets	£170
Ferro-cobalt	9/3 lb.
Aluminium 98/99%	£105
Metallic chromium—	
96/98%	3/- lb.
Ferro-manganese (net)—	
76/80%, loose	£13 0 0
76/80%, packed	£14 0 0
76/80%, export	£11 15 0
Metallic manganese—	
94/96%, carbonless	1/10 lb.
Per ton unless otherwise stated.	

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten	s. d. 2 6
Finished bars, 18% tungsten	3 0
Per lb. net, d/d buyers' works.	
Extras—	
Rounds and squares 3 in. and over	4d. lb.
Rounds and squares under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to 3/16 in.	1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅛ in.	3d. lb.
Do. under ½ in. × ⅛ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.
Bars cut to length	10% extra.
Scrap from high-speed tool steel—	
Scrap pieces	3d.
Turnings and swarf	1d.
Per lb. net, d/d steel makers' works.	

SCRAP.

	£	s.	d.
South Wales—			
Hvy. steel	2 17 6 to 3 0 0		
Bundled steel & shrngs	2 10 0 to 2 11 0		
Mixed iron & steel	2 10 0 to 2 12 6		
Heavy cast iron	2 17 6		
Good machinery for foundries	3	0	0
Cleveland—			
Heavy steel	2	15	0
Steel turnings	2	5	0
Cast iron borings	2	2	6
Heavy forge	3	12	6
Bushelled scrap	3	2	6
Cast-iron scrap	3 1 0 to 3	5	0
Lancashire—			
Cast-iron scrap	3	5	0
Hvy. wrought	3	2	6
Steel turnings	2	2	6
London — Merchants' buying prices delivered yard.			
Copper (clean)	48	0	0
Brass (clean)	37	0	0
Lead (less usual draft)	19	0	0
Tea lead	16	10	0
Zinc	16	10	0
New aluminium cuttings	76	0	0
Braziery copper	45	0	0
Gunmetal	46	0	0
Hollow pewter	170	0	0
Shaped black pewter	130	0	0

PIG-IRON

(f.o.t. unless otherwise stated).

N.E. Coast—	
Foundry No. 1	70/-
Foundry No. 3	67/6
Foundry No. 4	66/6
Forge No. 4	66/-
Hematite No. 1	75/6
Hematite M/Nos.	75/-
N.W. Coast—	
Hem. M/Nos. d/d Glas.	83/6
,, d/d Birm.	92/6
Midlands—	
Staffs. common*	—
,, No. 4 forge	60/-
,, No. 3 fdry.	65/-
Shrops. basic	—
,, Cold blast, ord.*	—
,, ,, roll iron*	—
* d/d Birmingham.	
Northants forge	54/-
,, fdry. No. 3	60/
Derbyshire forge	60/-
,, fdry. No. 3	65/-
,, basic	—
Scotland—	
Foundry No. 1	—
,, No. 3	73/6
Hem. M/Nos.	76/6
Sheffield (d/d district)—	
Derby forge	62/6
,, fdry. No. 3	65/-
Lincs. forge	—
,, fdry. No. 3	69/-
E.C. hematite	85/-
W.C. hematite	90/6
Lincs. (at furnaces)—	
Forge No. 4	—
Foundry No. 3	—
Basic	
Lancashire (d/d eq. Man.)—	
Derby forge	—
,, fdry. No. 3	73/6
Northants foundry No. 3	—
Dalzell, No. 3	105/- to 107/6
Summerlee, No. 3	91/6 to 100/-
Glengarnock, No. 3	91/6 to 100/-
Gartsherrie, No. 3	91/6 to 100/-
Monkland, No. 3	91/6 to 100/-
Coltness, No. 3	91/6 to 100/-
Shotts, No. 3	91/6 to 100/-

FINISHED IRON & STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

	£	s.	d.	£	s.	d.
Iron—						
Bars (cr.) nom.	9	15	0 to	10	15	0
Angles				—		
Tees to 3 united ins.				—		
Nut and bolt iron				—		
Hoops				14	10	0
Marked bars (Staffs.) f.o.t.				13	10	0
Gas strip				12	10	0
Bolts and nuts ¾ in. × 4 in.				15	5	0
Steel—						
Ship plates				8	2	0
Boiler plts.				10	10	0
Chequer plts.				10	5	0
Angles				7	12	6
Tees				8	12	6
Joists				7	12	6
Rounds and squares 3 in. to 5½ ins.				7	15	0
Rounds under 3 in. to ¾ in. (Untested)				8	0	0
				and upwards		
Flats, over 5 in. wide and up				9	2	6
Flats, 5in. to 1½in.				8	2	6
Rails, heavy				8	2	6
Fishplates				12	10	0
Hoops (Staffs.)				10	10	0
Black sheets, 24g.				10	7	6
Galv. cor. shts, 24g.				14	0	0
Galv. fencing wire 8g. plain				12	10	0
Billets, soft	6	0	0 to	7	0	0
Billets, hard				8	2	6
Sheet bars	5	12	6 to	5	15	0
Tin bars	5	12	6 to	5	15	0

PHOSPHOR BRONZE.

	Per lb.	basis.
Strip	1	2½
Sheet to 10 w.g.	1	2¾
Wire	1	3½
Rods	1	2¾
Tubes	1	8
Castings	1	2

Delivery 3 cwt. free.
10% phos. cop. £40 above B.S.
15% phos. cop. £50 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	per lb.
Ingots for raising	9d. to 1/3
Rolled—	
To 9 in. wide	1/3 to 1/9
To 12 in. wide	1/3½ to 1/9½
To 15 in. wide	1/3½ to 1/9½
To 18 in. wide	1/4 to 1/10
To 21 in. wide	1/4½ to 1/10½
To 25 in. wide	1/5 to 1/11
Ingots for spoons and forks	9d. to 1/5½
Ingots rolled to spoon size	1/- to 1/8½
Wire round—	
3/0 to 10 G.	1/6½ to 2/1½

with extras according to gauge.

AMERICAN IRON & STEEL

At Pittsburgh unless otherwise stated.	Dols.
No. 2X foundry, Phila.	20.76
No. 2 foundry, Valley	17.50
No. 2 foundry, Birm.	17.25
Basic	20.00
Bessemer	19.96
Malleable	19.26
Grey forge	18.76
Ferro-mang. 80% d/d	90.00
Bess. rails, h'y, at mill	43.00
O.-h. rails, h'y at mill	43.00
Bess billets	33.00
O.-h. billets	33.00
O.-h. sheet bars	34.00
Wire rods	43.00
	Cents.
Iron bars, Phila.	2.12
Steel bars	1.80
Tank plates	1.80
Beams, etc.	1.80
Skelp, grooved steel	1.80
Skelp, sheared steel	1.80
Steel hoops	2.30
Sheets, black, No. 24	3.00
Sheets, galv., No. 24	3.85
Sheets, blue an'l'd, 9 & 10	2.25
Wire nails	2.55
Plain wire	2.40
Barbed wire, galv.	3.25
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,,	20×10, ,,	—
,,	18¾×14, ,,	—
C.W.	20×14, ,,	17/3
,,	28×20, ,,	—
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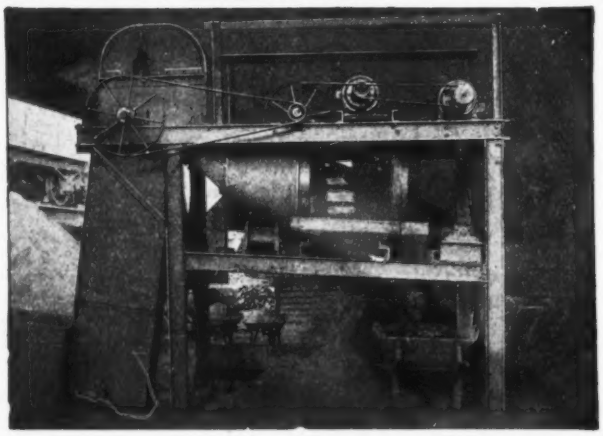

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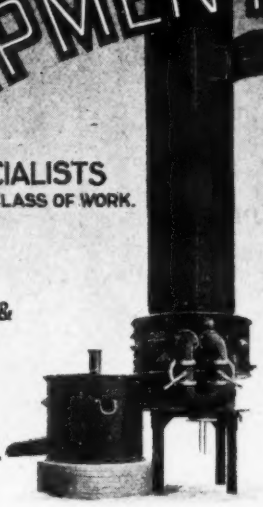

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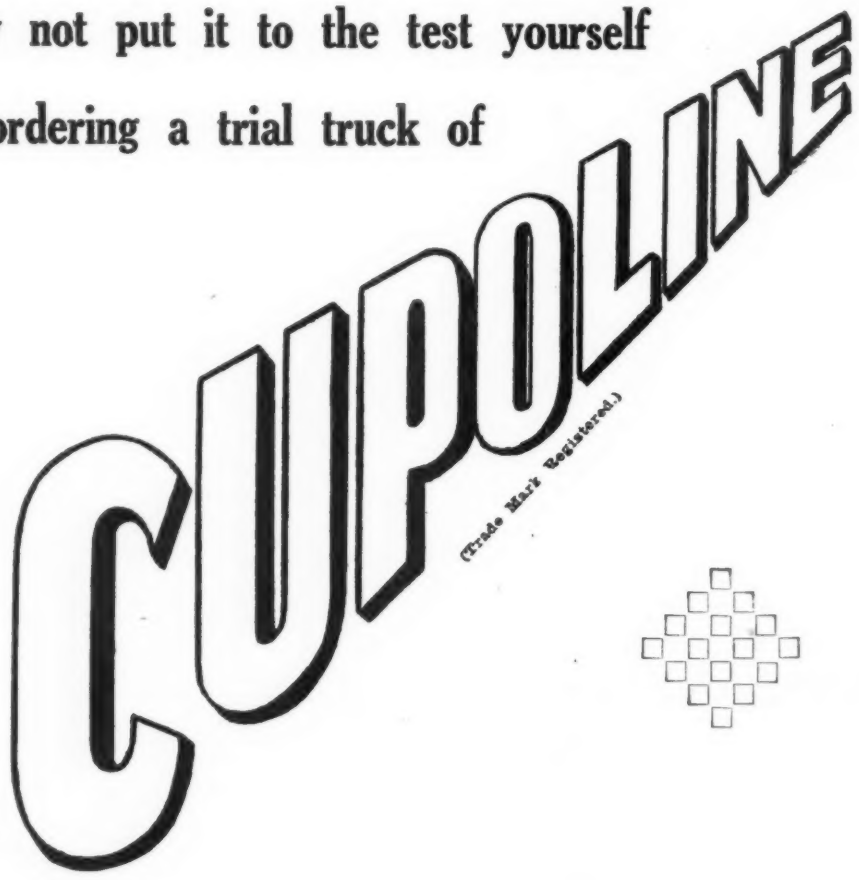

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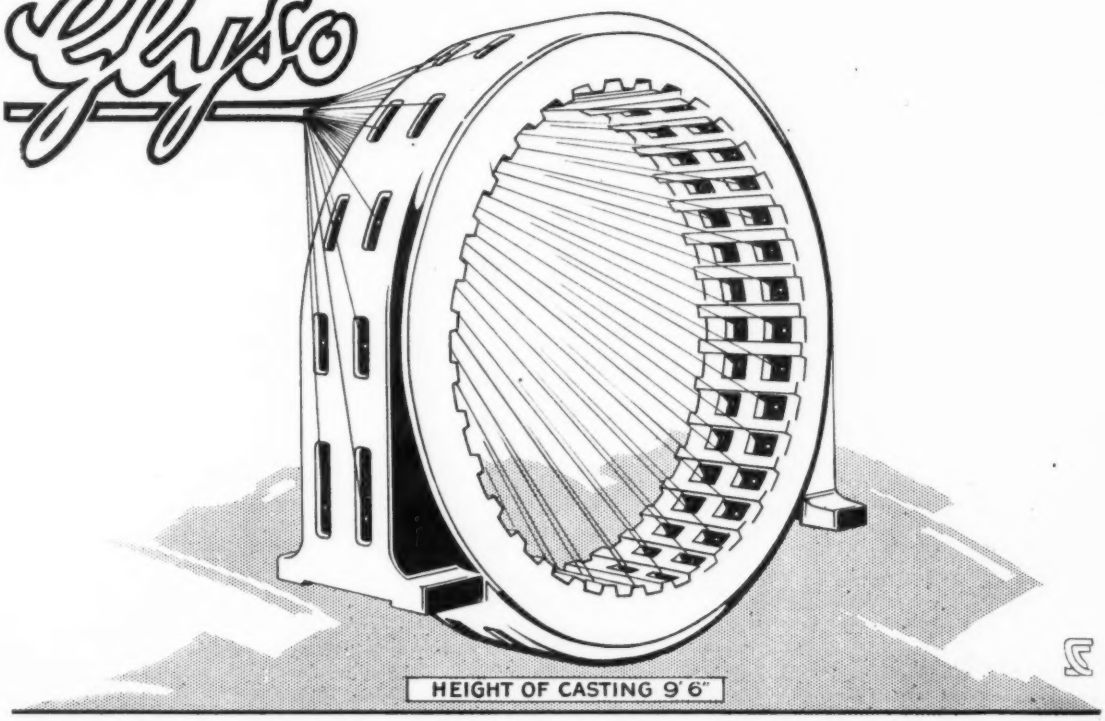

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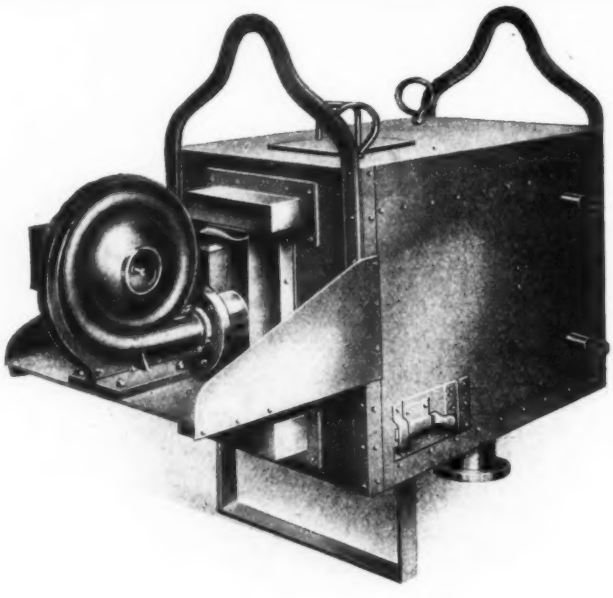

Fig. 296.

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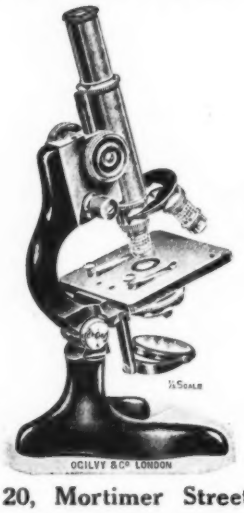

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	£	s.	d.		
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1896	4 15 0	4 17 6	5 0 0	5 0 0	5 0 0	4 17 6	4 17 6	4 17 6	4 17 6	5 0 0	5 7 6	5 7 6	4 19 9½
1897	5 7 6	5 7 6	5 7 6	5 5 0	5 0 0	5 0 0	5 2 6	5 2 6	5 2 6	5 2 6	5 0 0	5 5 0	5 3 5½
1898	5 5 0	5 5 0	5 5 0	5 7 6	5 13 9	5 15 0	5 15 0	5 15 0	5 17 6	6 0 0	6 5 0	6 7 6	5 14 3
1899	6 10 0	6 12 6	6 15 0	6 15 0	6 17 6	6 17 6	7 0 0	7 0 0	7 5 0	7 5 0	7 12 6	7 15 0	7 0 5
1900	7 15 0	8 0 0	8 2 6	8 5 0	8 5 0	8 7 6	8 7 6	8 2 6	8 2 6	8 0 0	7 10 0	7 10 0	8 0 7½
1901	6 15 0	6 12 6	6 5 0	6 0 0	6 0 0	5 10 0	5 15 0	5 17 6	6 0 0	5 17 6	5 17 6	5 15 0	6 0 5
1902	5 12 6	5 10 0	5 10 0	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 7 6	5 11 8
1903	5 6 3	5 6 3	5 7 6	5 12 6	5 12 6	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 0 0	5 8 9
1904	5 0 0	4 17 6	5 2 6	5 5 0	5 5 0	5 5 0	5 5 0	5 5 0	5 0 0	5 0 0	5 0 0	5 5 0	5 2 6
1905	5 5 0	5 7 6	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 12 6	6 2 6	6 12 6	6 12 6	5 14 4½
1906	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	7 2 6	6 13 4
1907	6 17 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	6 12 6	6 12 6	7 0 5
1908	6 2 6	6 2 6	6 2 6	5 17 6	5 17 6	5 17 6	5 17 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 16 3
1909	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 7 6	5 7 6	5 7 6	5 7 6	5 7 6	5 7 6	5 7 6	5 9 7
1910	5 16 3	5 17 6	5 17 6	6 1 6	6 2 6	6 2 6	6 2 6	6 2 6	6 2 6	6 7 6	6 7 6	6 7 6	6 2 3½
1911	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 7 6	6 9 0	6 7 8½
1912	6 16 3	6 17 6	6 17 6	7 5 0	7 7 6	7 7 6	7 7 6	7 12 6	7 12 6	7 12 6	7 14 6	7 17 6	7 7 3
1913	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 17 6	7 11 6	7 7 6	6 15 6	6 7 6	6 2 6	7 8 11½
1914	6 2 6	6 2 6	6 2 6	6 2 6	6 2 6	5 15 0	5 15 0	6 15 0	7 0 0	7 0 0	7 1 3	7 5 0	6 8 7½
1915	7 17 0	8 5 0	8 17 6	9 5 0	9 5 0	9 15 0	9 15 0	9 15 0	9 15 0	9 15 0	10 15 0	10 15 0	9 8 3½
1916	11 3 1½	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6
1917	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6
1918	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6	11 2 6¼
1919	11 2 6	13 12 6	13 12 6	13 12 6	17 2 6	17 1 3	17 0 0	17 15 0	17 15 0	17 15 0	17 17 6	18 5 0	16 1 9
1920	19 10 0	20 0 0	21 10 0	22 0 0	23 5 0	24 0 0	24 0 0	24 0 0	24 15 0	24 10 0	24 0 0	24 0 0	22 19 2
1921	22 10 0	20 12 6	19 0 0	17 10 0	17 10 0	16 6 0	14 10 0	14 3 4	13 10 0	11 15 0	10 0 0	9 12 6	15 11 7
1922	9 17 6	10 0 0	10 0 0	10 0 0	10 0 0	9 17 6	9 10 9	8 15 7½	8 14 0	8 12 6	8 12 6	8 12 6	9 7 8½
1923	8 18 1½	9 1 3	9 14 0	10 0 0	10 0 0	10 0 0	9 8 9	9 9 6	9 10 0	9 8 9	9 11 6	9 18 9	9 11 8½
1924	10 0 0	9 18 1½	9 17 6	9 17 6	9 17 2	9 11 3	9 15 0	9 15 0	9 9 4½	9 6 6	9 5 0	9 5 0	9 13 1½
1925	9 2 0	9 0 11½	9 0 0	8 15 9	8 10 3½	8 9 0½	8 6 3	8 2 6	7 19 0½	7 12 3	7 5 0	7 2 6	8 5 2½
1926	7 2 6	7 2 6	7 2 6	7 3 4	7 2 6	7 3 9	7 7 6	7 8 5½	7 9 0	7 12 6	7 16 3	8 0 6	7 7 7¼
1927	7 18 9	7 17 6	7 17 6	7 14 8½	7 13 9	7 12 6	7 12 6	7 12 6	7 12 6	—	—	—	—

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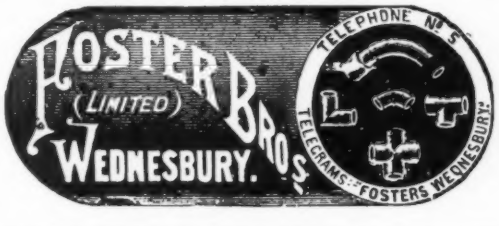

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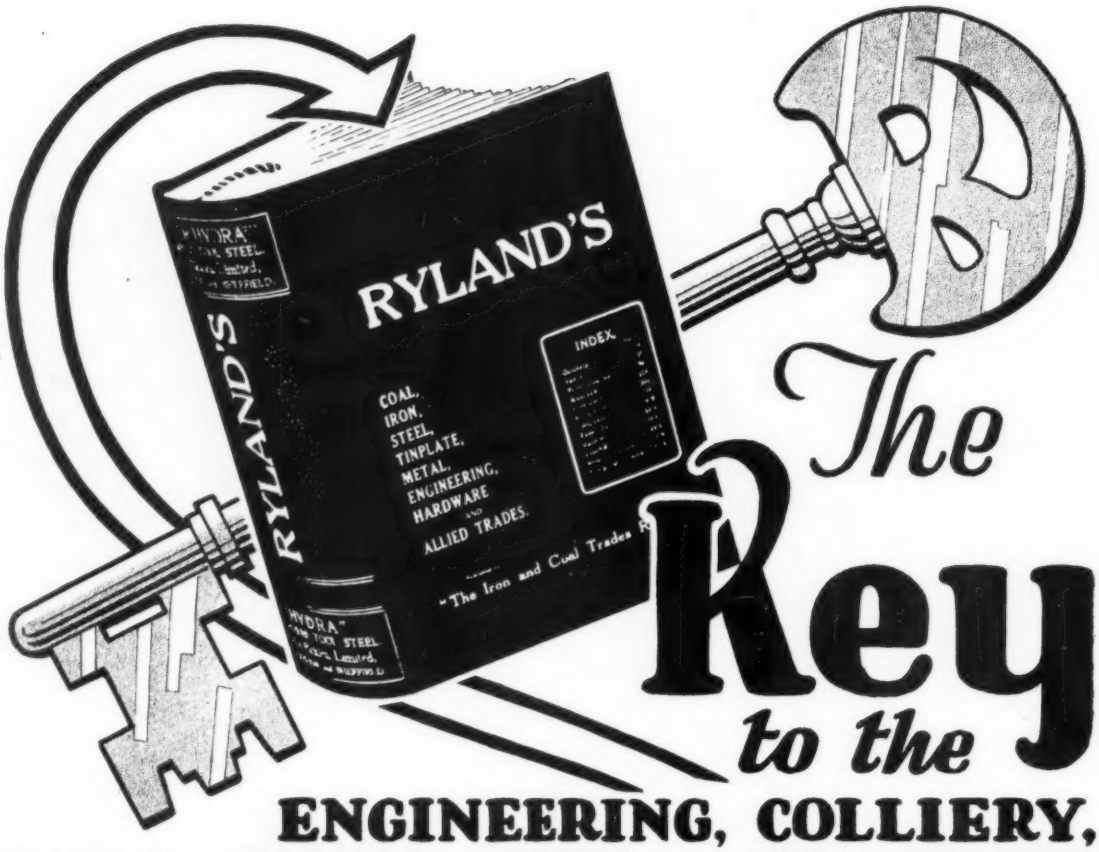

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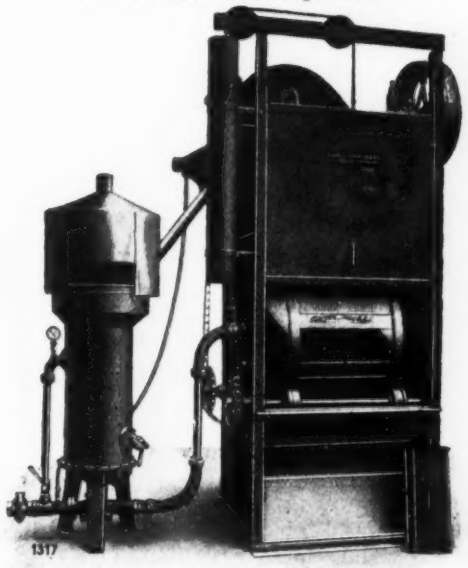

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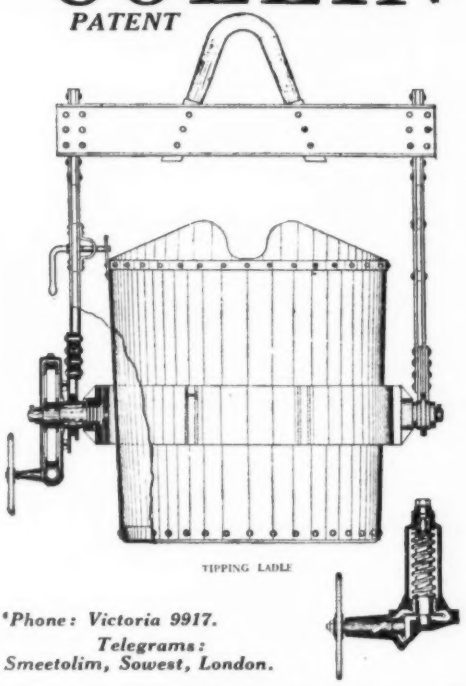
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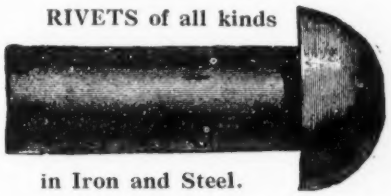

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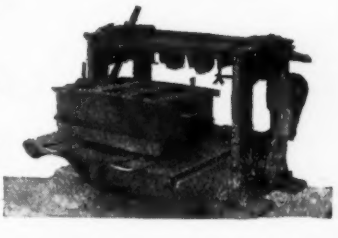

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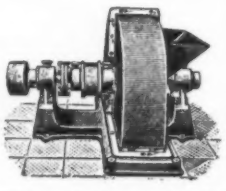

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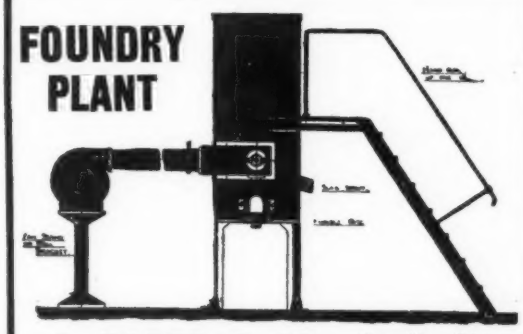

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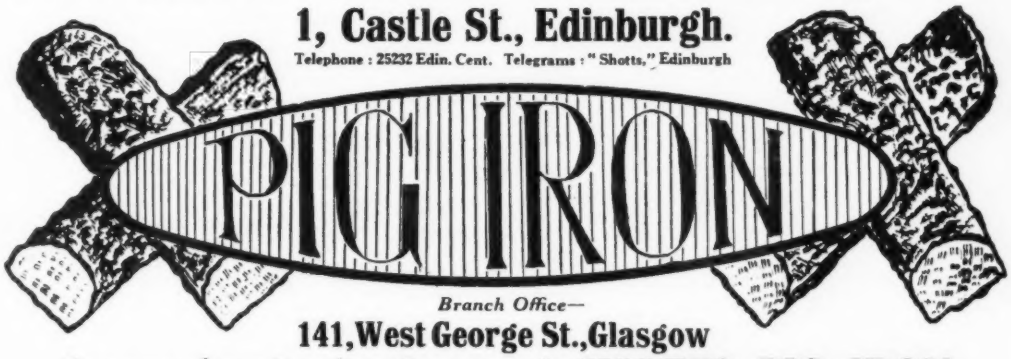

Branch Office—
141, West George St., Glasgow

Approximate Analyses of SHOTTS PIG IRON

FOUNDRY AND FORGE QUALITIES.

	Iron. %	Graphitic Carbon. %	Combined Carbon. %	Silicon. %	Sulphur. %	Phos. %	Mang. %
No. 1	91.38	3.30	.25	3.25	.02	.70	1.10
No. 3 Soft	91.67	3.40	.20	2.90	.03	.70	1.10
No. 3 Medium	91.95	3.25	.35	2.60	.05	.70	1.10
No. 3 Hard	92.49	3.00	.45	2.30	.06	.70	1.00
No. 4 Soft	93.03	2.90	.50	1.80	.07	.70	1.00
No. 4 Hard	93.60	2.75	.65	1.40	.10	.70	.90
Mottled	93.95	2.00	1.50	.90	.15	.70	.80
White	94.35	.60	2.80	.55	.30	.70	.70

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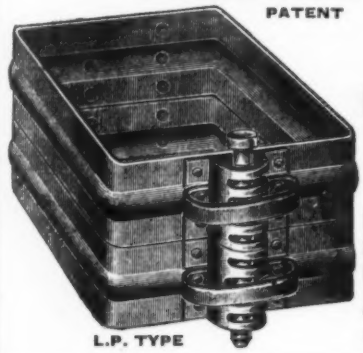
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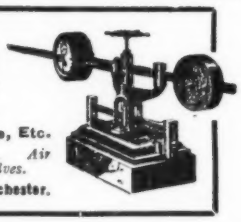

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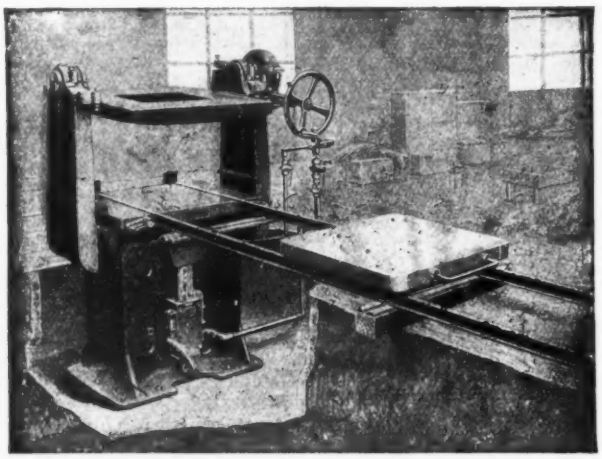

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